European Journal of Psychology of Education (2025) 40:119
https://doi.org/10.1007/s10212-025-01033-6

Who benefits motivationally? How the direction of performance feedback affects feedback perception and motivation to improve multiple document comprehension

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Received: 21 September 2024 / Revised: 8 September 2025 / Accepted: 15 October 2025 /
Published online: 7 November 2025

Abstract
The direction of feedback (i.e., emphasizing positive or negative aspects about the object of feedback) and students' feedback perception are major factors driving their engagement in the feedback process and motivation. Positive performance feedback tends to be more readily accepted and perceived as more useful, enhancing motivation for further engagement. Negative performance feedback may be valued less and may reduce the motivation to improve one's skill. Against this background, it is surprising that research about multiple document comprehension (MDC) feedback and its perception is rare although MDC is an essential skill for university students. The present study examines the relationship between the direction of performance feedback about the MDC skill, feedback perception, and motivation to improve MDC. Participants were 202 university students. Students' MDC skill was assessed by a standardized test, which provided individual feedback after test completion. Performance feedback was based on the MDC skill using Weighted Likelihood Estimates. Feedback perception and motivation to improve were assessed by self-report questionnaires. The direction of performance feedback was found to be partially relevant for feedback perception and motivation to improve MDC. A high perceived feedback usefulness played a role for the motivation to improve MDC. Students receiving a positive performance feedback and students who perceived the feedback as useful benefited motivationally. Therefore, feedback usefulness seemed to be especially important for the motivation to improve MDC.

Keywords Multiple document comprehension · Performance feedback · Feedback perception · Motivation · Self-assessment

Extended author information available on the last page of the article

Introduction

University students are typically exposed to complex reading situations, where multiple document comprehension (MDC) is needed. Thus, they need the ability to successfully understand, represent, and integrate information from multiple texts of the same topic (Mahlow et al., 2020). Despite its importance, MDC tasks are perceived as effortful and challenging for many students (e.g., Hahnel et al., 2019b); Mahlow et al., 2020). MDC is neither explicitly taught in secondary education in Germany nor systematically trained in university courses, making self-regulated practice essential.

To develop MDC independently, students need motivation to improve in this area. Motivation is considered a key factor in students ' ability to engage with cognitvely demanding tasks such as MDC. The process of MDC involves higher-order skills such as source evaluation or integrating of conficiting information. These skills require cognitive effort, which students are more likely to invest when they perceive tasks as valuable, expect to suceed, and believe that the benefits overweigh costs (Eccles & Wigfield, 2020). Thus, motivation plays an important role in driving students to engage, persist, and improve their MDC skill.

Therefore, examining what factors predict such motivation is crucial. One important factor in this regard is feedback, which is a well-established influence on students' learning behavior and motivation (e.g., Harks et al., 2014; Hattie & Timperley, 2007; Narciss & Huth, 2004; Tricomi & DePasque, 2016). In particular, computer-based feedback has been shown to significantly foster students' motivation and learning outcomes (Shute, 2008; Van der Kleij et al., 2015). While research has largely focused on feedback from teachers, peers, or automated systems in general learning contexts, less is known about how feedback affects motivation in specific domains such as MDC.

Feedback in MDC-specific reading situations, such as preparing for exams or presentations or doing homework, can help students identify strengths and weaknesses in their reading process. Since MDC is cognitively demanding and often lacks direct instructions, feedback might be important to shape students' perceptions of their skills and, thereby influencing motivation to improve MDC. Feedback that is perceived as useful, specific, and acceptable can enhance students' expectancy, increase value and reduce costs to improve MDC.

As will be elaborated in the following, we assume that the direction of performance feedback and feedback perception are crucial predictors for motivation to improve MDC. We also expect that feedback perception serves as a mediator for the relationship between performance feedback and the motivation to improve MDC.

In this paper, we first present a theoretical framework which aims to describe how performance feedback and its perception affects motivation in specific reading situations by integrating several research theories and models (e.g., Eccles & Wigfield, 2020; Ilgen et al., 1979; Rouet et al., 2017). It focuses on the question of how feedback affects motivation in the MDC domain and reviews the role of the direction of feedback and its perception as predictors for motivation, integrated in a model of MDC. We then examine the assumptions of the introduced theoretical framework about the relation of the direction of performance feedback, feedback perception, and motivation to improve MDC.

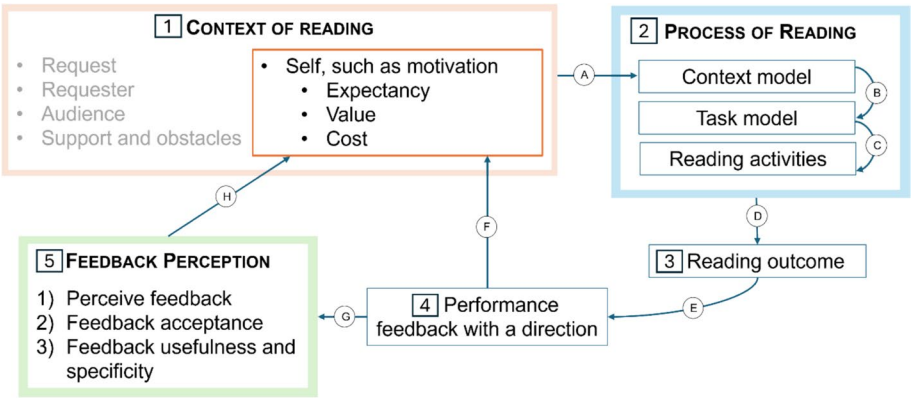

Fig. 1 Theoretical framework of the present study

Theoretical framework of the present study

The framework that is presented in the following aims to explain how feedback about a reading outcome influences motivation (Fig. 1). It refers to a specific domain (MDC) and specific reading situations in which performance feedback is received (e.g., exam, homework) and consists of three components: motivation (Section "Motivation to improve MDC"), the reading process when reading multiple documents (Section "Multiple Document Comprehension"), and the feedback (Section "Feedback"). Before explaining the links between the individual components and considering the whole framework, the underlying constructs will be outlined. Therefore, the different parts and connections of the framework are described in detail in the following.

Motivation to improve MDC

Motivation can relate to two different aspects that are both relevant for the framework: the reading motivation and the motivation to improve MDC. In the following, when only the term "motivation" is used, both aspects are meant. Motivation to improve MDC is relevant for university students when reading multiple texts or training MDC. It appears especially important in reading situations, where feedback is provided. When students receive performance feedback, they should try to improve their performance in subsequent reading tasks and, therefore, need this specific form of motivation.

In the present study, we refer motivation to improve MDC on the expectancy-value theory and assume that motivation to improve MDC consists of the expectancy, the value, and the costs to improve MDC (Eccles & Wigfield, 2020). Broadly, the expectancy-value theory assumes that individuals' expectancies for success and the value they have for succeeding influence performance, effort, persistence, and choices of which tasks to pursue (Wigfield & Eccles, 2000). *Expectancies* are individuals' beliefs about how well they will perform on future tasks (Eccles & Wigfield, 2020), such as the improvement of MDC. Expectancies are influenced by students' beliefs about their ability. Although ability beliefs are theoretically distinct from expectancies, they often overlap empirically (Eccles & Wigfield, 1995). In our terms, the expectancies to improve MDC are important for further

reading processes and fostering of MDC. The *value* of a task refers to how much an individual wants to pursue a task (Eccles, 2005). We assume that individuals who value the improvement of MDC are more likely to engage in this behavior to pursue a task (e.g., Barron & Hulleman, 2015). *Costs* refer to negative consequences of engaging with a task and can be defined as "what the individual must give up to do a task […] as well as the anticipated effort one will need to put into task completion" (Eccles, 2005, p. 113). Thus, costs are considered negative aspects of the improvement of MDC that individuals experience. For instance, individuals perceive that it would cost them too much time or too much resources to improve in MDC.

Research about motivation to improve MDC found that the perceived value of MDC partially predicted the motivation to improve MDC (Zink et al., 2023). However, there is no research on what other factors, such as feedback and its perception, might predict motivation to improve MDC. Therefore, we specifically aim to examine motivation to improve MDC as a dimension of motivation in reading situations where performance feedback is provided.

In the context of the framework, motivation to improve MDC as well as motivational constructs in general, including reading motivation, are a part of the self-dimension of the RESOLV model (Fig. 1, *Component 1*) of the context (Rouet et al., 2017). In the following, the RESOLV model will be described in more detail.

Multiple document comprehension

The part of the theoretical framework referring to the multiple document reading process (Fig. 1, *Component 1–3*) originates from the RESOLV model (Rouet et al., 2017).

The RESOLV model refers to the *Documents Model Framework* (Britt & Rouet, 2012). The Documents Model Framework describes how readers construct coherent mental representations based on multiple texts of the same topic. The Documents model includes a mental model where a representation of the texts' contents is constructed (integrated mental model) and a intertext model containing information of the texts' sources and how they are related (e.g., Britt & Rouet, 2012). To form a documents model, readers connect the integrated mental model and the intertext model. In order to construct an ideal representation of multiple texts (i.e., documents model), several *strategies* have been identified that are beneficial in multiple document situations (Wineburg, 1991): Sourcing, contextualization, and corroboration. Sourcing means taking information about the sources into account (Hahnel et al., 2019a). Contextualization means that readers relate the information from the documents to their prior knowledge, and corroboration is the comparison of information across texts (Wineburg, 1991). Overall, the documents model is an ideal representation of multiple texts and corroboration, sourcing, and contextualization are strategies to construct the representation. That means, the Documents model is a model that describes what mental representations of multiple documents look like. The RESOLV model focuses more on reading as problem solving by suggesting that individuals construct mental representations of the reading context and reading task (Rouet et al., 2017).

More precisely, RESOLV postulates that reading decisions on multiple texts are informed by reading goals that are shaped by situational and individual aspects (Rouet et al., 2017). RESOLV is based on the idea that reading multiple texts takes place within a physical and social context that sets conditions and resources for reading. The context of reading multiple texts includes several dimensions that have direct impact on the reading process: the request, the requester, the audience, support and obstacles, and the self

(Rouet et al., 2017). The self-dimension refers to readers' attribution, beliefs, expectations regarding themselves as readers or, readers' self-assessment of their task value, and cost associated with the activity (Rouet et al., 2017). An example for a context would be a computer-based test for self-assessment purposes. The computer system (e.g., programmed by the teacher: requester and audience) gives an instruction to read three different texts and answer questions afterwards (request). The space and time to work on the test can be chosen individually, and the materials are different texts on one topic shown in a digital learning environment (support and obstacles). The readers' assessment of themselves (self) is also important in this context, that is for example the MDC self-concept or the motivation to read multiple texts.

RESOLV describes that readers construct a context model based on this individual context *(Path A*; Rouet et al., 2017*)*. With the context model as a base, readers build a task model *(Path B)* that represents the schematic plans on how to achieve the subjective reading goal based on a benefit-cost-analysis (Rouet et al., 2017). This leads to the reading activities, which are sequences of processes, decisions and actions derived from the task model *(Path C*; Rouet et al., 2017*)*. These reading activities result in reading outcomes (*Path D*; Rouet et al., 2017). In the context of reading situations in which feedback is received, reading outcomes are, for example, a grade after an exam or presentation. Referring to the example of a computer-based test, a possible reading outcome would be a test score based on correctly solved questions.

These reading outcomes represent performance indicators that are often embedded in specific learning environments. These environments can shape students' motivational processes, because in self-paced and computer-based learning contexts even more motivation is required compared to more instructed settings (e.g., Cho & Heron, 2015). Such learning environments are increasingly common in higher education and share features typical of distance and hybrid learning formats. Direct teacher-student interaction is reduced, and learners need a higher autonomy in these learning environments (e.g., Talsma et al., 2023). These characteristics make feedback particularly important, as it often serves as a primary source of guidance and regulation for students' learning process. Therefore, understanding how students perceive and use feedback in these settings is essential for fostering motivation. To explore this further, feedback and its role in the framework will be described in the following.

Feedback

After completing the reading process, learners may receive feedback on their reading outcomes (*Component 4*). Feedback can be defined as "all post-response information that is provided to a learner to inform the learner on his or her actual state of learning on performance" (Narciss, 2008, p. 127).

Referring to our framework, the RESOLV model does not explicitly elaborate potential effects of feedback, even though feedback seems to be an important influence for motivational factors. Therefore, the model by Ilgen et al. (1979) can help better understand the process of how feedback on reading outcomes in the context of MDC results in changes of the motivation (*Path F–H*).

Feedback can enhance students' understanding of their current performance level and provide guidance on how to improve. Various types of feedback have been examined in the literature, including teacher-generated feedback (Shute, 2008), peer feedback (e.g., van Popta et al., 2017), and computer-based feedback (e.g., Zheng, 2016). While most studies

focus on traditional instructional settings, computer-based feedback has gained increasing relevance in digital learning environments due to its scalability and immediacy. Research indicates that such feedback can significantly foster students' engagement and motivation to learn, as it provides timely, individualized, and adaptive information (Shute, 2008). Further, computer-based feedback positively affects both motivation and learning outcomes, highlighting its particular importance in digital contexts (Van der Kleij et al., 2015). Recent meta-analyses suggest that the effectiveness of feedback not only depends on its content but also on the mode of delivery (e.g., oral, written, digital), level of elaboration, and perceived relevance to the learner (e.g., Wisniewski et al., 2020).

In addition to these structural and contextual characteristics, the evaluative tone of feedback (i.e., direction) also plays a crucial role in how feedback is perceived by learners.

Direction of feedback

Generally, feedback can communicate positive, neutral, or negative qualities about a product, action, or person (Fong et al., 2019). Accordingly, feedback normally has a certain direction (i.e., positive or negative). In a natural setting (e.g., a grade after a test), feedback informs students about their performance. Thus, the better the performance, the more positive the feedback is and the other way around. That means, in natural settings performance feedback is often inextricably linked to performance itself. Referring to our example, a higher test score (i.e., a better performance in the test) means a more positive feedback, whereas a lower test score means a more negative feedback.

The direction of feedback is important for motivation (*Path F*): It can be assumed that positive performance feedback has other effects on the motivation than negative performance feedback. Research postulate that negative feedback, especially mild negative feedback (Anderson & Rodin, 1989), might enhance motivation, because negative feedback provides an opportunity to correct mistakes and improve task performance (e.g., Cianci et al., 2010). However, negative feedback could make students feel helpless. This is also supported by the meta-analysis from Fong et al. (2019) that found negative feedback to reduce intrinsic motivation. Moreover, feedback influences motivation through emotional and cognitive mechanisms. Emotionally, positive feedback may foster feelings of competence and satisfaction, which can enhance (intrinsic) motivation. Negative feedback might lead to frustration or discouragement, especially when perceived as vague or unjustified (e.g., Ilgen et al., 1979). Cognitively, feedback can lead to a re-evaluation of one's abilities and task strategies. According to Cognitive Evaluation Theory (Deci & Ryan, 1985), feedback that supports a sense of competence and autonomy tends to increase (intrinsic) motivation. Moreover, feedback perceived as informative rather than controlling can help students develop more accurate expectations and a clearer understanding of task requirements, which is central to expectancy-value theory (Eccles & Wigfield, 2020). Thus, both affective and cognitive responses to feedback are relevant in explaining its motivational impact.

In the context of MDC, Maier and Richter (2014) found that positive feedback (i.e., feedback that compared students' performance to a lower standard of comparison) on undergraduates' reading skills increased their motivation to use demanding reading strategies and reduced their tendency to favour belief-consistent claims while reading conflicting texts. However, other studies have questioned the effectiveness of such feedback in improving academic performance (e.g. Cheng et al., 2015; Patchan et al., 2016; Shute, 2008). For instance, Cheng et al. (2015) investigated how students respond to praise in peer

assessment settings. They found that students often appreciated positive feedback but they rarely used it to improve their work, especially when the praise lacked specificity. Patchan et al. (2016) investigated written peer feedback in writing tasks, where students provided comments on their peers' essays. They found that learners perceived feedback as more helpful when it was critical and constructive, even if it was not affectively positive. Similarly, Shute (2008) highlighted in a comprehensive review of formative feedback across various learning contexts that overly general praise (i.e., unspecific and person-focused comments) can be ineffective. In contrast, feedback that is timely, specific, and focused on the task is beneficial. Although these studies were not limited to computer-based feedback systems, their findings are highly relevant to computer-based feedback, where the design can ensure that feedback is delivered in a timely manner, targeted to learners' specific errors or strategies, and framed constructively. Overall, these studies suggest that positive feedback, while affectively satisfying, does not always lead to measurable academic improvement unless it contains specific information and is perceived as useful.

To further clarify how feedback affects students' motivation to improve MDC, we differentiate the impact of feedback on each of the three motivational components: expectancy, value, and cost. Feedback that highlights students' strengths or gives concrete suggestions for improvement can enhance students' expectancy by fostering their belief in their capability to improve MDC (e.g., Harks et al., 2014; Ilgen et al., 1979). Feedback that emphasizes the relevance or usefulness of MDC might increase the value to improve MDC (e.g., Tricomi & DePasque, 2016). Additionally, feedback can influences cost to improve MDC by either reducing the perceived effort or frustration (e.g., by providing manageable next steps for improvement), or increasing costs when feedback is vague or overly ciritical (Narciss, 2008).

Feedback perception

Beside the direct effect of the direction of performance feedback on the motivational constructs (Fig. 1, *Path F*), the direction of performance feedback also affects feedback perception (*Path G*), which has an influence on the motivation (*Path H*). This indicates that the feedback perception might mediate the relation between the direction of performance feedback and the motivation. In general, "feedback perceptions refer to the outcomes of how recipients spontaneously experience the feedback content as provided by an external source or the feedback process as a whole—in terms of cognitive, metacognitive, motivational, and/or affective reactions" (Strijbos et al., 2021, p. 2). In other words, feedback perception refers to the extent to which learners perceive feedback to be supportive for their learning (Gibbs & Simpson, 2003). Feedback perception can be differentiated into three important aspects: Feedback acceptance, feedback usefulness and feedback specificity. Feedback acceptance addresses the extent to which the receivers perceive feedback as being consistent with their self-perception (Kinicki et al., 2004). The feedback receiver needs to accept the feedback in order to follow the advice of the feedback (Bohndick et al., 2020). Further, the information in the feedback needs to be seen as useful or valuable (London, 1994) to promote students' actual use of the information provided (Harks et al., 2014). In addition, feedback specificity might also be a part of the feedback perception because it correlates with feedback acceptance, feedback usefulness and motivation (see Gunkel, 2014). Feedback specificity can be defined as „the level of information presented in feedback messages" (Shute, 2008, p. 157). Feedback in general that is not specific can lead to lower levels of learning or reduced motivation to respond to the feedback (e.g., Ashford, 1986;

Kluger & Denisi, 1996). Further, specific feedback has been shown to enhance perceived usefulness and acceptance, even when containing negative content (Hattie & Timperley, 2007; Shute, 2008). When negative feedback is vague, it may be perceived as more threatening and less helpful, potentially undermining motivation. In contrast, specific negative feedback can be interpreted as constructive, as it enables students to understand their weaknesses and identify clear paths for improvement. Similarly, when positive feedback is provided motivation might increase when it highlights precisely what was done well, thus reinforcing effective strategies. Therefore, specificity appears important, especially because it can buffer the potential demotivating effect of negative feedback and enhance the credibility of positive feedback.

To better understand how such characteristics unfold their effects, Ilgen et al. (1979) proposed four stages of how feedback results in behavior change. Adapted for our framework, performance feedback needs to be perceived and accepted as accurate. Further, the learner needs to perceive the feedback as useful and specific. At this point, the direction of feedback is important because it can decide whether the feedback is accepted and, perceived as useful and specific or not (*Path G* of our framework). If the feedback is perceived as positive, learners might have a higher motivation. That means, accepting feedback and perceiving it as useful and specific are requirements for motivation and lead to higher expectations and values as well as lower perceived costs. (*Path H*). Referring to our example, a student with a higher test score receives positive performance feedback, whereas a student with a lower test score receives negative feedback. The positive performance feedback is more likely to be accepted, perceived as useful and specific than the negative performance feedback. This results in higher reading motivation and motivation to improve MDC, meaning that the student with higher test scores have higher expectancies, values and perceive lower costs in further MDC reading tasks and when improving this skill. In contrast, the student with a lower test score might have less or no motivation, meaning lower expectancies, values and higher perceived costs.

As mentioned above, the feedback direction might also directly affect the perception (*Path G*). Ilgen et al. (1979) postulate in their review that positive feedback is perceived more accurately than negative feedback due to a defense mechanism, meaning the positive feedback is more pleasant and readily accepted because it fits with one's self-image. Negative feedback may be denied because of the "unwillingness to accept such knowledge about himself or herself" (Ilgen et al., 1979, p. 354). Further, positive feedback was found to increase perceived feedback usefulness and feedback acceptance (e.g., Wang et al., 2015). That means, the more positive the performance feedback, the more positive the feedback perception.

Although the present framework primarily focused on the effects of positive and negative feedback on feedback perception and students' motivation to improve MDC, it is important to briefly consider the potential role of neutral feedback in this process. According to Cognitive Evaluation Theory (Deci & Ryan, 1985), even feedback that does not provide evaluative content can influence perceived competence and support autonomy. Neutral feedback can enhance or undermine motivation depending on whether it is interpreted as informative or controlling. When feedback is perceived as autonomy-supportive and provides clear, competence-related information, it can foster motivation. In high-stakes academic contexts, the emotional impact of feedback becomes especially relevant. Negative feedback might demotivate students by threatening their perceived competence, while positive feedback can create unrealistic expectations. Therefore, neutral feedback which emphasizes information about performance without strong evaluative judgement might be helpful (Boud & Molloy, 2013; Hattie & Timperely, 2007).

Mediation

Feedback perception (i.e., acceptance, usefulness and specificity) mediates the relationship between the direction of performance feedback and students' motivation to improve MDC. Specifically, the direction of feedback influences how the feedback is perceived by students. For instance, positive feedback might be perceived as more motivating when it is also seen as specific, useful and accepted. These feedback perceptions shape motivational responses: when feedback is perceived as specific and useful, students are more likely to feel capable to improve MDC (higher expectancy), recognize the importance of the task (higher value), and experience less emotional or cognitive costs (lower costs). When feedback is accepted, students are more likely to internalize its message, which enhances its potential to influence motivation to improve MDC. Thus, the feedback perception explains how and why the direction of feedback influences students' motivation to improve MDC. It is not just the direction of feedback that matters, but how students interpret and process feedback.

Links of the theoretical framework

After describing the components and their connections in the previous theoretical background, we want to summarize these again and embed them in the theoretical framework. The reading process as part of the framework originates from the RESOLV model (Rouet et al., 2017) including the context (*Component 1*) with the motivational constructs (expectancy, value and cost) as a part of the self dimension of the context. *Component 2* describes the reading process, which is relevant for understanding the other steps of the framework; however, the processes of reading are not the primary focus of the present study. Based on the individual context, readers construct a context model *(Path A)*, build a task model *(Path B)*, which leads to the reading activities *(Path C)*. Reading outcomes (*Component 3*) are the result of this reading process (*Path D;* e.g., test scores, grades). The following components feedback and feedback perception (*Component 4 and 5*) and their relationships (*Path F, G, and H*) are mainly based on the model by Ilgen et al. (1979). This part presents the influence of the direction of performance feedback and feedback perception on motivation. More specifically, *Path F* describes that the direction of feedback affects motivation. *Path G* represents the influence of the direction of performance feedback on feedback perception and *Path H* the effects of feedback perception on motivation. Note that *Path F* and *Path H* illustrate that the motivation and the subsequent context model can be subject to updating as a function of the activity outcomes and feedback (Rouet et al., 2017). Based on the updated context model, reading goals, plans and activities might also be updated.

The present study

Based on the theoretical framework (Fig. 1), we address the following research question: How does the direction of performance feedback affect students' motivation to improve MDC, and what role does feedback perception play in this relationship? Therefore, the present study aims to examine whether the direction of feedback on the performance in an MDC test predicts students' feedback perception and their motivation to improve MDC. We also examined the effects of feedback perception on the motivation

to improve MDC. Feedback perception was investigated as a mediator of the relation between performance feedback and the motivation to improve MDC.

We derived the following hypotheses:

- H1 (Path F): Performance feedback is positively related to students' motivation to improve MDC.

  More specifically, we assume that positive performance feedback increases students' expectancy and value but lower perceived cost. This assumption is supported by research showing that positive feedback enhances self-efficacy and engagement by supporting students' perceived skill (Hattie & Timperely, 2007). This, in turn, can strengthen their beliefs in success (expectancy), perceived value of feedback and reduce the cost they associate with the task.
- H2 (Path G): Performance feedback is positively related to their feedback perception (acceptance, usefulness and specificity).

  Positive feedback might be perceived as more constructive and encouraging. Therefore, students might accept it more readily, consider it useful and specific (e.g., Fong et al., 2019). These perceptions are crucial because they shape how students cognitively and emotionally engage with feedback.
- H3 (Path H): Feedback perception (acceptance, usefulness and specificity) predicts motivation to improve MDC.

  Each component of feedback perception might play a unique motivational role. When feedback is accepted, students' openness to change increases. Feedback usefulness enhances students' belief that acting on feedback leads to a meaningful progress, thereby strengthening the perceived relevance of the learning task and justifying the effort required. Specific feedback provides clear and actionable information that helps students understand what needs to be improved. (Ilgen et al., 1979; Shute, 2008).
- H4 (Component 4 → Component 5 → Component 1): Feedback perception mediates the relationship between performance feedback and motivation to improve MDC.

We assume that the direction of feedback influences how students perceive feedback, which in turn influences motivation to improve MDC. For instance, feedback perceived as useful and specific might help students identify helpful strategies, which leads to lower perceived costs.

Method

Sample

The sample consisted of 202 students of different majors (72% females, 80% master students, $M_{age} = 25.5$, $SD_{age} = 4.6$) from three German universities. University students were recruited through advertisement e-mail, in university courses, university social-media groups, and an obligatory seminar. 472 students of all studies registered for this study. Most participants studied German studies (about 16%), psychology (about 10%), or primary school teaching with different subject combinations (about 5%). However, 146 students did not start the study or had only missing data. One student was excluded due to a suspicious pattern of straightlining. We also excluded students who did not have enough

data to estimate a person parameter for MDC skill and students without data on feedback perception, because these are main variables in this study.

The present study was part of a project where students needed to work on the MDC tests at two different times. The present study included all students who participated at the first point of measurement. Students' compensation for participation in the study followed different patterns, because compensation was adjusted due to recruitment challenges during the COVID-19 pandemic so that some students received 15 to 25€ after finishing a second test in the winter semester 2021/22, whereas other students received course credit, test subject minutes or 10€ after the first test. Students who took part in the first test had also the opportunity to take part in the second test. Detailed information about the compensation can be found in (Zink et al., 2023).

The data used for the present study stem from the same sample as the data used in (Zink et al., 2023), although the sample sizes differ slightly due to different exclusion criteria. However, the present study is a separate analysis and the topic of both studies, hypotheses, and variables (except motivation to improve MDC) do not overlap.

Design and procedure

After participants registered for study participation and received a password to access a learning management system (Moodle), they worked on a computer-based MDC test to assess their MDC skill (Schoor et al, 2020). Therefore, the present study was conducted in a self-regulated, computer-based environment, where students completed the MDC test independently from home. The participation was not part of any specific course of institutional setting, allowing students to engage with the material at their own pace and schedule. This learning environment shows key features of distance and online learning environments such as minimal instructional guidance and high autonomy. Prior to beginning the test, students provided their informed consent for participation. Afterwards, the test began with a tutorial that explained its functions, such as navigation, note taking, highlighting and source accessing, and questions about demographic variables and further questionnaires that were not relevant for the present study. Participants were randomly assigned to one of two test versions, each comprising two units with different content. Participants had the opportunity to take the test whenever they wanted and did not need to finish the test in a single session. After completing the test, students received automatically generated feedback and rated their feedback perception and motivation to improve their MDC skill. The MDC test with feedback took about 1.5 to 2 h, and participants were allowed to work on it from December 2020 to July 2021. After receiving feedback, students also had the opportunity to train their MDC skill with self-study material until November 2021. Afterwards, students were invited to take the second MDC test. However, very few students took part in the second test. The data of the self-study material and the second MDC test were not part of the present study.

Material and instruments

MDC skill assessment

The MDC test consisted of several units and the students had to work on two units. Each unit of the test included two or three texts with 11 to 17 items. The units belonged to four different domains (history, physics, literature, and literature studies) in order to assess

MDC as a generic cross-disciplinary competence (Schoor et al., 2020). The texts and items were in German. Most texts of the units contained redundant or complementary information. Conflicting information was rare and conflicting on a surface level (e.g., information about the age of a story protagonist). To avoid prior knowledge effects, the content of the texts was invented, except for the physics domain. Each item measured one of four cognitive requirements: Corroboration of information across texts, integration of information across texts, comparison of sources and source evaluations across texts and comparison of source-content links across texts (see Schoor et al., 2020). Each unit started with an introductory page to inform students about the number of texts and items, the time limit and the setting of a reading goal. The next page displayed the first text. The top bar provided information about the elapsed time and buttons to navigate between texts and items and to exit a unit. During the test session, students could navigate freely between items and texts. Each text page provided a button to present the source information about the text. While reading the texts, students could highlight text passages and write comments. There were unit-specific time restrictions, but students could exit the units at any time. When the time expired, the unit ended automatically. The MDC test was built with the CBA ItemBuilder (Rölke, 2012).

Based on the dichotomously scored item responses (0 = incorrect, 1 = correct), we estimated person parameters with a Rasch model (weighted likelihood estimation, WLE; Warm, 1989) to represent the MDC skill (WLE reliability of.62). The same MDC test was examined in more detail in a validation study, which provides empirical evidence supporting the construct validity of the MDC test score. Specifically, the MDC score (WLE) showed significant correlations with students' final school exam grades. Moreover, the MDC score was significantly predicted by the level of university studies (i.e., bachelor vs. master students) and prior university performance. The model of the present study used the item parameters of a scaling sample of 508 students of different majors (78% females, 53.3% bachelor students, $M_{age} = 22.8$, $SD_{age} = 3.8$; details reported in Hahnel et al. (2021); Mahlow et al. 2020).

Feedback

After taking the MDC test, the participants received individual feedback. The structure of the feedback for all students was as follows: First, students got information about the relevance of MDC in general, task requirements and MDC-supporting strategies. Second, feedback about the MDC skill with individual information about correctly solved answers,

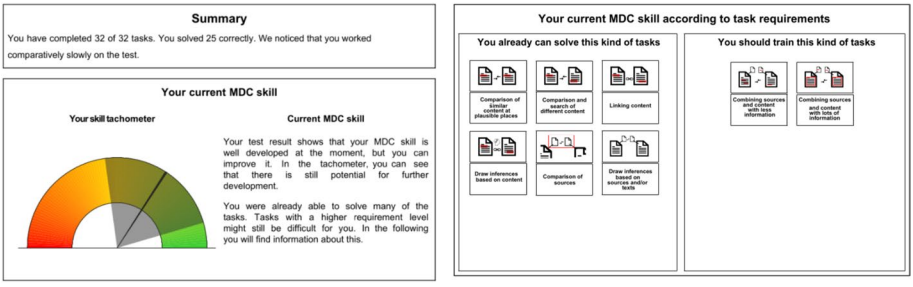

Fig. 2 Example of feedback about MDC skill

the speed of working on the test, the current MDC skill, and strengths and weaknesses (see Fig. 2) was provided. Third, participants received log data-based feedback about their individual strategy use during test processing. In the end, students were provided with an individual recommendation which aspects they should train with the self-study material.

Feedback about the MDC skill was developed according to competence levels that were defined in line with the definition of competence areas by Hartig (2007) and with the interest in which cognitive requirements students could cope with on a certain level. Using the item parameters of the scaling sample (Hahnel et al., 2021; Mahlow et al., 2020), nine competence levels were distinguished. Table 1 shows the nine competence levels regarding the cognitive requirement students needed to master on a certain level. Each level represents what a person can do, with higher levels including the proficiencies described at lower levels. For example, a student who reached competence level 3, received feedback that they can already link content and compare similar content at plausible places. An example for the task requirement "Linking content" is when students are asked to connect information from different texts that often share similar wording. "Draw inferences based on sources and/or texts" refers to tasks in which students need to derive conclusions either only from source information or through a combination of source information and text content.

The feedback was based on the individual WLE scores according to which students were classified into one level and received individual feedback about their MDC skill. That means, this feedback was the representation of the MDC skill, indicating that the higher the MDC skill, the more positive the feedback was and the other way around. More precisely, the WLE score specifies the individual content and, therefore, the direction of the feedback about the MDC skill (more information is provided in the supplementary material).

For the log data-based feedback, event-based log data of each participant were collected and processed such as button clicks or time stamps. The rationale for processing these log data was based on the idea that students move through the test by moving from state to state. For example, first they read the text (state: reading), then they work on a task (state: task). In the Finite-State Machine approach (Kroehne & Goldhammer, 2018) that was used in the present study, these states and transitions between them are modelled. This allows easy definition and analysis of behavior during test-taking. Process indicators were built that represented the following MDC-supporting strategies: sourcing, corroboration and a general working strategy. Participants received information about these strategies and feedback on their individual strategy use during test processing as well as questions to reflect on their use of these strategies.

Table 1 Competence levels

Level	Additional task requirement
1	No task requirement
2	Linking content
3	Comparison of similar content at plausible places
4	Comparison of sources
5	Combining sources and content with few information
6	Draw inferences based on sources and/or texts
7	Comparison and search of different content
8	Draw inferences based on content
9	Combining sources and content with lots of information

See Author (2023)

Feedback perception

Feedback perception was measured as feedback acceptance, feedback usefulness, and feedback specificity on a five-point Likert scale. The feedback acceptance was measured with four items adapted from Stone and Stone (1984; e.g., "The feedback is an accurate assessment of my performance in the test"; ω = .83[1]). To assess feedback usefulness, we used a four-item scale, adapted from Bürgermeister et al., (2011; e.g., "The feedback helps me to see where I can still improve."; ω = .92). The feedback specificity scale was adapted from Klebl (2006) and consisted of three items (e.g., "The received feedback was clear and concrete."; ω = .79). Feedback acceptance correlated with feedback usefulness ($r = .42$; $p < .001$) and feedback specificity ($r = .57$; $p < .001$). Feedback usefulness also correlated with feedback specificity ($r = .76$; $p < .001$). Confirmatory factor analysis (CFA) yielded an acceptable model fit with three factors ($\chi^2 = 106.929$, $df = 41$, CFI = .94, TLI = .92, RMSEA = .09, SRMR = .05). To test the robustness of our findings, we examined alternative factor structures by randomly splitting the sample in half and rerunning a CFA. However, these model adjustments resulted in even poorer fit indices, suggesting that the original model provided the best fit to the data.

Motivation to improve MDC

Motivation to improve MDC was assessed with an adapted and translated version of the "Expectancy-Value-Cost" questionnaire by Barron et al. (2017), consisting of three items for expectancy, three items for value, and four items for cost on a five-point Likert scale. CFA of motivation to improve MDC with three factors yielded an inadequate model fit ($\chi^2 = 96.770$, $df = 32$, CFI = .91, TLI = .88, RMSEA = .10, SRMR = .09). Therefore, we split the sample and modified the model based on the first sub-sample (sub-sample A). One item was deleted from expectancy to improve MDC and one from costs to improve MDC. Therefore, expectancy to improve MDC consisted of two items (e.g., "I know I can improve in dealing with multiple texts."; $r = .54$), the value to improve MDC contained three items (e.g., "I think it's important to improve in dealing with multiple texts."; ω = .89), and costs to improve MDC consisted of three items (e.g., "I am not able to spend enough time to improve in dealing with multiple texts."; ω = .66). The modified model from sub-sample A (n = 94) was cross-validated with sub-sample B, showing a good fit ($n = 102$, $\chi^2 = 18.620$, $df = 18$, CFI = 1.0, TLI = 1.0, RMSEA = .02, SRMR = .05). The modified model had also a good fit in the total sample ($\chi^2 = 27.473$, $df = 18$, CFI = .98, TLI = .98, RMSEA = .05, SRMR = .04; Schermelleh-Engel et al., 2003).

Data analysis

All analyses were conducted using Mplus 8.8 (Muthén & Muthén, 1998–2017). For the variables included in the main analyses, 2.3% of the data were missing. These missing values were handled by full-information maximum likelihood (FIML; Enders, 2010). The WLE was included as a manifest variable, whereas the other variables were modelled as latent variables in each model.

[1] Since Cronbach's α often presents no ideal measure of internal consistency, internal consistency was quantified by McDonalds ω (Dunn et al., 2014).

In order to investigate H1 – H3, we conducted structural equation models for each hypothesis. To analyze H4, we defined a mediation model with feedback acceptance, feedback usefulness, and feedback specificity as mediators for the relationship between performance feedback and motivation to improve MDC. Structural equation model was conducted using maximum likelihood estimation, which assumes multivariate normality. We applied Maximum Likelihood (ML) estimation to assess model parameters. Additionally, bootstrapping with 5000 resamples was used to obtain robust standard errors and confidence intervals, thereby addressing potential violations of multivariate normality and enhancing the robustness of indirect effect estimates.

A power analysis using G*Power (Version 3.1.9.7; Faul et al., 2009) was conducted to determine the required sample size for testing the hypothesized relationships using multiple regression (f^2 =.15, α =.05, power =.80). The analysis indicated that a minimum of 114 participants would be required. As the present study employed latent regression and mediation analyses with a sample of 202 university students, the available sample size exceeds this threshold and is considered adequate for the planned analyses.

Results

Descriptive statistics

Table 2 reports descriptive statistics and zero-order correlations for the variables. The MDC skill (WLE) and, therefore, the direction of the performance feedback was significantly correlated with the feedback acceptance (r =.30) and cost to improve MDC (r =-.17). The feedback acceptance (M =3.48), usefulness (M =3.58), and specificity (M =3.65) indicated that students accepted the feedback, perceived the feedback as helpful and specific to recognize how to improve their MDC skill.

Performance feedback (MDC skill) and motivation to improve MDC (H1)

Figure 3 shows the structural equation model for the relationship between the MDC skill (i.e., the direction of the performance feedback) and the motivation to improve MDC. A higher MDC skill predicted lower perceived cost to improve MDC (ß =-.20; p =.02). There was no statistically significant relation between performance feedback and expectancy (ß =.13; p =.14) and value to improve MDC (ß =.01; p =.90).

Performance feedback (MDC skill) and feedback perception (H2)

The structural equation model depicted in Fig. 4 revealed that the MDC skill and, therefore, the direction of the performance feedback significantly predicted the feedback acceptance (ß =.27; p <.001). However, there were no significant effects on feedback usefulness (ß =-.09; p =.23) and specificity (ß =.13; p =.10).

Feedback perception and motivation to improve MDC (H3)

Figure 5 shows the structural equation model for the relation between the feedback perception and the motivation to improve MDC. A higher perceived usefulness of the

Table 2 Means, Standard Deviations, and Correlations for the Manifest Variables

Variable	*N*	*M*	*SD*	1	2	3	4	5	6	7	8
1. MDC skill (WLE)	202	−0.08	0.79								
2. Feedback acceptance	197	3.48	0.84	.30**							
3. Feedback usefulness	199	3.58	0.94	-.08	.34**						
4. Feedback specificity	197	3.65	0.87	.11	.46**	.63**					
5. Expectancy to improve MDC	196	3.80	0.76	.11	.27**	.52**	.39**				
6. Value to improve MDC	195	3.73	0.91	-.00	.12	.58**	.33**	.57**			
7. Cost to improve MDC	196	2.96	0.86	-.17*	-.07	-.00	-.04	-.21**	-.05		

* $p < .05$; ** $p < .01$

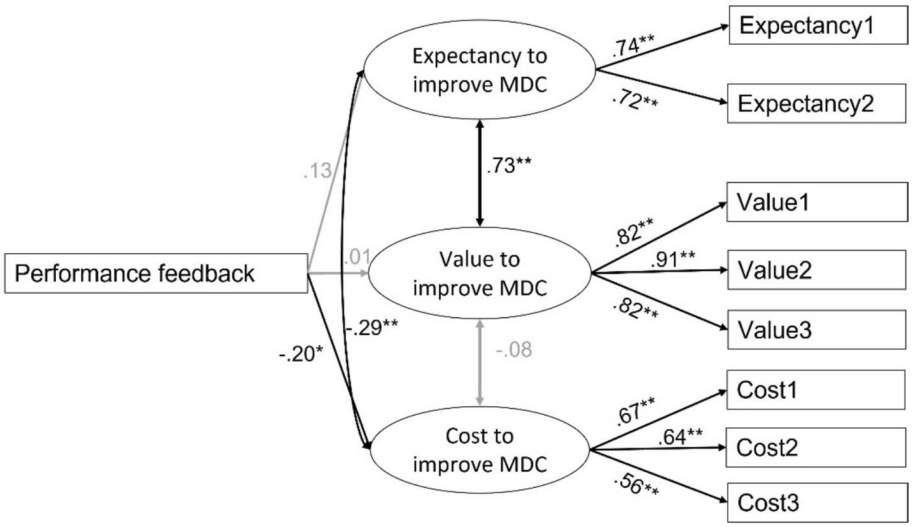

Fig. 3 Structural equation model with performance feedback (MDC skill) and motivation to improve MDC; $n = 198$, $\chi^2 = 41.228$, df = 23, CFI = .97, TLI = .95, RMSEA = .05, SRMR = .06. *Note*. * $p < .05$; ** $p < .01$

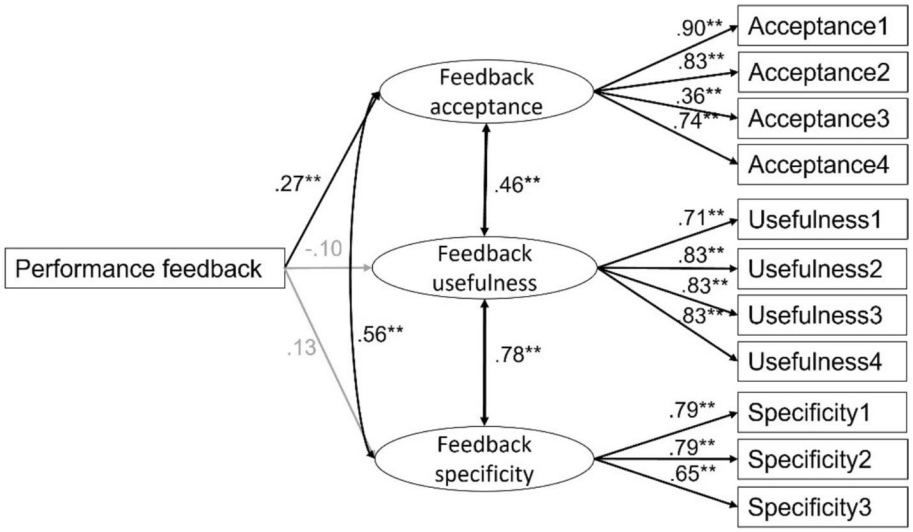

Fig. 4 Structural equation model with performance feedback (MDC skill) and feedback perception; $n = 202$, $\chi^2 = 138.114$, df = 49, CFI = .92, TLI = .90, RMSEA = .10, SRMR = .05. *Note*. * $p < .05$; ** $p < .01$

feedback predicted the value (ß = .81; $p < .001$) and the expectancy to improve MDC (ß = .44; $p < .001$) but not the cost to improve MDC (ß = -.04; $p = .79$). Feedback acceptance and feedback specificity did not predict the motivation to improve MDC.

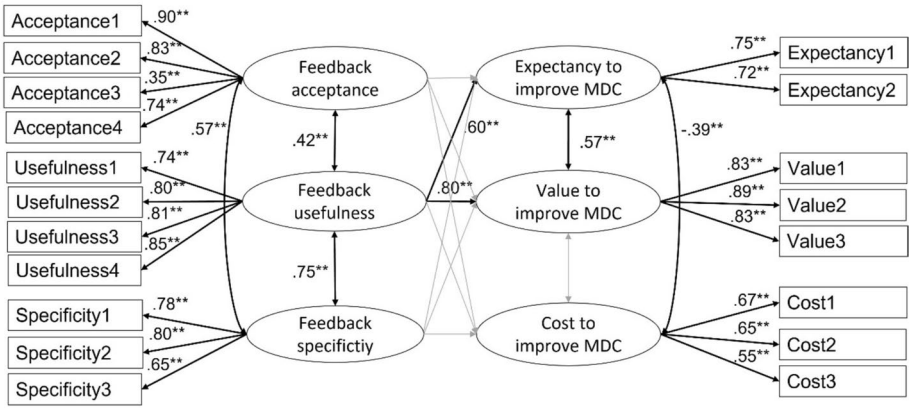

Fig. 5 Structural equation model with feedback perception and motivation to improve MDC; $n = 202$, $\chi^2 = 272.429$, df = 138, CFI = .93, TLI = .91, RMSEA = .07, SRMR = .05. *Note*. * $p < .05$; ** $p < .01$

Mediation analysis (H4)

The requirements for the mediation analysis were not fulfilled (Baron & Kenny, 1986) because the analyses revealed only partially significant effects. Thus, model fit indices indicated a bad fit to the data: $\chi^2(\text{df}) = 469.015$, df = 157, CFI = .83, TLI = .80, RMSEA = .10, SRMR = .17. The direction of performance feedback was only associated with feedback acceptance ($\beta = .26$, $p < .001$). Feedback perception was also only partially significantly related to motivation to improve MDC. Specifically, feedback usefulness predicted value ($\beta = .67$, $p < .01$) and expectancy ($\beta = .58$, $p < .001$).The indirect effects from the direction of feedback to motivation via feedback perception were not significant.

Discussion

The role of performance feedback and its perception for the motivation to improve MDC

The present study examined the relation between performance feedback, feedback perception, and the motivation to improve MDC based on a theoretical framework developed to relate theories of multiple documents reading with effects of feedback on students' behavior. We expected that the direction of performance feedback positively predicts motivation to improve MDC (i.e., expectancy, value and cost). Expectancy to improve MDC and value to improve MDC were not dependent on the feedback direction. Further, we assumed that the direction of performance feedback positively influences feedback perception (H2). The analysis indicated that the MDC skill is only related to the feedback acceptance and not to feedback usefulness and specificity. At last, we investigated the relationship between feedback perception and motivation to improve MDC (H3). The analysis revealed only partial effects of the feedback perception on motivation to improve MDC. Thus, feedback usefulness predicted the expectancy and the value to improve MDC.

The results showed that a higher MDC skill, resulting in a more positive report in the performance feedback, was related to lower cost to improve MDC. This indicates that students who already have a high MDC skill perceived lower cost to improve their MDC skill. Cost refers to any negative consequences of engaging in a task, or in our study, to improve MDC (Eccles, 2005). It might be possible that students who already showed a good performance in MDC and received positive feedback probably do not expect negative consequences. Students might think that it is easier to improve their MDC skill when they already showed a good performance. However, it might be even more difficult and requiring time and energy to improve when a learner already has a high level of MDC skill, as research suggests that further achievement in performance gets more challenging once a certain level of expertise is reached (e.g., Dweck, 2006; Ericsson et al., 1993). Thus, the students might not be aware of this increasing effort required for further improvement and think it is easier and, therefore, connected with lower cost to improve.

Moreover, students' advanced MDC skill also influenced how they respond to feedback, meaning a higher MDC skill led to higher feedback acceptance. The feedback process model after Ilgen et al. (1979) proposed that particularly favorable feedback messages would lead to higher acceptance of the feedback. Recent studies support this assumption: Recipients were more accepting of favorable (positive) feedback than unfavorable (negative) feedback (e.g., Anseel & Lievens, 2006; Brett & Atwater, 2001). Extending previous findings to MDC, students who received positive performance feedback accepted the feedback more than students who received negative performance feedback.

We further expected that performance feedback also affects the feedback usefulness and specificity, which was not the case. This finding is inconsistent with previous research: Various studies indicated that students mostly prefer specific as well as elaborated feedback which is perceived as more useful than brief and general feedback (e.g., Peterson & Irving, 2008; Strijbos et al., 2010; van der Kleij et al., 2012). The feedback in the present study was elaborate and specific since it provided information about strengths and weaknesses and indicated ways to improve. Accordingly, the descriptive statistics showed that students rated the feedback usefulness and the feedback specificity high. Therefore, it might be possible that the MDC skill itself and, therefore, the content of the performance-based feedback was not relevant for the perceived usefulness and specificity of the feedback. Since the presented feedback provided elaborate and specific information, the direction of the feedback might not be that relevant for the students. That means, even though the feedback in the present study provided information about a negative performance, it might still be perceived as useful and specific because of the elaborateness and specificity of the feedback.

In this context, the type of feedback might be also interesting and linked to feedback usefulness and specificity. Prior research indicates that teacher feedback is often perceived as more specific and helpful than computer-based feedback (e.g., Shute, 2008; Voerman et al., 2012). Automated feedback is perceived more generic and less personalized than teacher feedback (e.g., Narciss, 2008). Additionally, the social dimension of feedback plays a critical role: feedback from a teacher tends to be more readily accepted and more motivating for students, due to the social relationship and perceived expertise (Kulhavy & Stock, 1989). Although automated feedback systems have become increasingly complex (e.g., AI-based tutoring or adaptive learning environments), they still face limitations in terms of social presence, emotional responsiveness and contextual nuance. These human aspects of feedback might still give teacher-generated feedback an advantage, particularly when motivation and acceptance are central (Shute, 2008). Future research could take this into account and provide feedback from other sources.

It should also be mentioned that individual differences might influence how feedback is perceived and processed. For example, students with high levels of self-efficacy might interpret feedback, especially negative feedback, as constructive and motivating. However, students with lower self-efficacy might perceive it as threatening (e.g., Bandura, 1997; Dweck, 2000). Similarly, students' prior experiences with feedback might shape how they perceive feedback. These findings suggest that the effectiveness of feedback is not only determined by its content or direction but also by learners' internal states and cognitive-emotional processes. Therefore, future research should address factors that influence feedback perception beside the direction of feedback.

The importance of investigating factors beyond feedback direction is further supported by the current findings: Students who perceived the feedback as useful had a higher expectancy and value to improve MDC more than students who perceived the feedback less useful. However, feedback acceptance and specificity showed no significant effects on the motivation to improve MDC. The relevance of feedback usefulness is also proposed by Ilgen et al. (1979) because feedback needs to be perceived as useful in order to have positive effects on the motivation to improve. Similarly, Misiejuk et al. (2021) found that learners engaged more actively with peer feedback when they perceived it as useful. In such cases, students were more likely to acknowledge their errors, express an intention to revise their text, and praising feedback's usefulness. In contrast, students who perceived feedback as less useful tended to be more defensive, for example by disagreeing with the claims. These findings highlight the importance of designing feedback that is meaningful to students. Further, this aligns closely with our findings on the importance of feedback perception, underscoring that the perceived usefulness of feedback is a key driver of engagement and motivation. Consequently, it seems to be important to provide feedback that is perceived as useful and, therefore, is elaborate and specific (e.g., Strijbos et al., 2010). Future research could also investigate which factors determine feedback usefulness. Therefore, it might be beneficial to examine different parts of the feedback experimentally, such as providing strength and weaknesses in the feedback or not.

The findings indicated that especially students who already have a high MDC skill perceived lower costs to improve MDC and also rated the feedback acceptance higher than students with a lower MDC skill and, therefore, did benefit from performance feedback motivationally. This leads to the question of how also students with a poorer performance in MDC can benefit motivationally from performance feedback. Future research should address this question for example by collecting and analyzing qualitative data. A possible answer to this question provides the present study: The perceived usefulness of the feedback. Students perceived the feedback as useful, which led to a higher motivation to improve MDC. However, we do not know, if this also leads to an improvement of the MDC skill. Nevertheless, the feedback needs to be designed accordingly by providing elaborate and specific information. Future research could examine which parts of the MDC feedback were especially helpful, specific, and increased the motivation to improve MDC. Moreover, it should be investigated whether feedback that is perceived as useful, together with a higher motivation to improve MDC, leads to a higher performance in MDC.

As a practical implication, teachers in higher education might design feedback in a way that not only communicates performance outcomes but also enhances motivational components. For instance, educators should aim to provide specific and elaborate feedback, in particular when pointing out weaknesses. Further, teacher should pair this feedback with a neutral or encouraging framing that avoids triggering defensive reactions. This means that even students with low skills could benefit motivationally from feedback.

Theoretical framework

With regard to the developed framework, the results of the present study could not confirm all relationships or only parts of the relationships. For example, for *Path F* the results showed that only costs to improve MDC were influenced by the direction of the performance feedback. Future research could investigate the different paths and components of the framework in more detail (e.g., examining the different aspects of feedback perception separately). Furthermore, the theoretical framework includes motivation in a more general way. Motivation has different dimensions, especially when reading multiple texts, the reading motivation is important for the reading process. However, the present study focused on the motivation to improve MDC. Future studies could also examine the different dimensions of motivation and focus on reading motivation and how feedback affects it.

Furthermore, it is important to mention that the relationships in the framework might be influenced by individual learner characteristics. Prior experiences with feedback, students' baseline motivation, and self-related beliefs such as self-esteem can shape how feedback is perceived and how it subsequently affects motivation (e.g., Kluger & Denisi, 1996). For instance, learners with negative past experiences might be more skeptical towards feedback or interpret critical feedback as more threatening. Similarly, students with low self-esteem may be more sensitive to negative feedback, which could lead to disengagement rather than constructive effort (e.g., Kluger & Denisi, 1996). On the other hand, individuals with high baseline motivation might generally be more open to feedback and more likely to use it for self-regulated learning, regardless of its valence (Dweck, 2006; Zimmerman & Schunk, 2011). Cognitive biases might play also a role and influence feedback interpretation. For instance, students might focus more on critical elements of feedback or selectively attend to information that aligns with their prior beliefs about their abilities (e.g., Confirmation bias; Nickerson, 1998). These variables may act as moderators in the feedback–motivation relationship and should be integrated in the theoretical framework in future research.

These moderating factors might help to explain how the direction of feedback and feedback perception influences motivation to improve MDC.

In addition to shaping motivational responses, these factors might also affect what follows: How students perceive feedback and how motivated they feel to improve MDC can influence their subsequent learning behavior and strategy use. For instance, when feedback is perceived as specific, useful, and is accepted, students might be more likely to engage in adaptive strategies such as re-reading texts more carefully, seeking additional information, or revising their answers more thoroughly. In contrast, if feedback is perceived as vague or not helpful, students might disengage or rely on surface-level strategies. Although the influence on learning behavior and strategy use is already implicitly embedded in the theoretical framework through the updating context model, reading goals and activities, these aspects could be examined more directly and in more detail in future research.

In this context, students' intention to act (i.e., their commitment to engage in future MDC practices) could also extend the theoretical framework. While the present study focuses on motivational constructs (i.e., expectancy, value and cost), intention represents a subsequent phase that builds on these motivational constructs and reflects the translation of motivational beliefs into concrete action plans. Future research could address this construct and how feedback not only influences students' motivation but also sustained engagement in learning activities.

In conclusion, the theoretical framework is a suitable base for the present study and the derived hypotheses, but it should be investigated further and optimized. It is also

possible to adapt the framework on other reading situations beside reading multiple texts or focus other reading outcomes.

Limitations

First, the sample mainly consisted of master students who worked in the context of an obligatory seminar on the first MDC assessment or were compensated with up to 25€ for processing the MDC test twice. That means, the intention of the students was not necessarily to assess and improve MDC because the MDC assessment was not implemented in a natural learning setting. In terms of a long-term implementation at the university, students would not be rewarded. However, it was difficult to recruit students for this study during the COVID-19 pandemic. Therefore, we decided to reward students which might lead to a methodological problem for measuring motivation constructs. Further research should examine if students who are paid for participation behave differently than students who are intrinsically motivated to take the test. Moreover, students did not receive the same amount of money. As outlined in the method section, we increased the compensation over time due to a challenging recruitment of participants. We cannot exclude that the different compensations might have influenced motivation differentially.

Further, the data collection entails certain limitations. The study relied on self-report questionnaires to assess students ' perceptions of feedback and their motivation to improve MDC. While such instruments provide valuable insights into learners ' subjective experiences, they also have limitations: responses may be influenced by social desirability, memory biases, or differences in self-assessment accuracy (e.g., Schwarz, 1999). Future studies could address this limitation by triangulating self-reports with behavioral or performance-based measures to capture a more comprehensive picture of students' responses to feedback.

Another limiting factor relates to the feedback and its perception. In the present study, we used the MDC skill to examine the effects on feedback perception and motivation. However, other characteristics of the feedback might have influenced the perception and motivation to improve MDC, such as the presentation of the feedback, the wording and formulations, the graphics, the timing, the complexity, and length or that the feedback was computer-generated. Future research should also take these characteristics into account when examining the effects on feedback perception and motivation to improve MDC.

Furthermore, it is important to address how missing data were managed in the analyses. Although missing data in our study were minimal (2.3%) and handled using Full Information Maximum Likelihood (FIML), which is considered a robust method under the assumption of missing at random (MAR), this assumption cannot be directly tested. Therefore, while we believe the impact of missing data on our findings is negligible, we acknowledge that the reliance on MAR represents a potential limitation and should be considered when interpreting the results.

One further potential limitation of our analysis concerns the RMSEA (0.09) value of feedback perception, which is slightly above the ideal threshold of 0.08. The value is considered as mediocre but still acceptable (Schermelleh-Engel et al., 2003). This might indicate a suboptimal model fit. However, this model provided the best fit to the data compared to alternative factor strtuctures.

At last, it needs to be explicitly mentioned that the positivity or negativity of the performance feedback is inextricably linked to the MDC skill, because the feedback is based on the WLE. This means that the feedback effects found are also skill-related

effects. Therefore, we cannot specifically assume feedback effects or skill-related effects. Future studies could conduct an experimental design in which students are presented with positive or negative feedback regardless of their MDC skill.

Conclusion

The study points out the relevance of the feedback usefulness for students' motivation to improve MDC. Among the components of feedback perception, feedback usefulness seems to be a driving force for the motivation to improve MDC, underlining its crucial role in the motivational process. By linking feedback direction and perception to established motivational components (expectancy, value and cost), our findings expand the theoretical understanding of their relationship in self-regulated learning processes in complex academic tasks such as MDC. It emphasizes that feedback is not only an external stimulus but also a subjectively interpreted input that partially shapes learners' motivation. In particular, the findings suggest that when feedback is perceived as useful, students are more likely to feel competent and autonomous, which enhances their willingness to invest effort in improving MDC. From a practical perspective, the results imply that providing students with elaborate and specific feedback can support their motivation to improve MDC. Thus, instructors or teachers should be encouraged to design feedback that students perceive as useful.

Future research should investigate which specific characteristics of feedback contribute to its perceived usefulness. Relevant aspects might include the content of feedback (e.g., the balance between positive and negative elements, the specificity of improvement suggestions) or the mode of presentation (e.g., written vs. oral, individualized vs. generic). It is also relevant to understand why feedback usefulness plays such a crucial role for motivation to improve MDC, and whether this motivation leads to better MDC performance. More research about the determinants of the motivation to improve MDC is needed to understand what is necessary to enhance this motivation because MDC is an important skill for university students and needs to be fostered. Nevertheless, it is beneficial to provide students with feedback about their MDC skill, especially elaborate feedback to show students their strength and weaknesses as well as ways to improve their performance.

Supplementary information The online version contains supplementary material available at https://doi.org/10.1007/s10212-025-01033-6.

Funding Open Access funding enabled and organized by Projekt DEAL. The project on which this report is based was funded by the German Federal Ministry of Education and Research, funding code 01PK19008.

Data material and/or code availability The publication of the data on OSF is planned. The corresponding link will be submitted later.

Declarations

Ethics approval The project "MultiTex-Transfer" was reviewed by the Ethics Comitee of the University of Bamberg, Germany, and an approval granted.

Consent Students provided their informed consent for participation, before processing the assessment.

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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Current themes of research:

Feedback, Motivation, and Engagement in the context of MDC.

Most relevant publications in the field of Psychology of Education:

Schoor, C., Zink, T., Mahlow, N., Hahnel, C., Deribo, T., Kroehne, U., Goldhammer, F., Naumann, J.,& Artelt, C. (2024). Diagnostik des Leseverständnisses multipler Texte: MultiTex. [Diagnostics of reading comprehension of multiple texts: MultiTex.] In T. Richter & W. Lenhard (Eds.), Diagnose und Förderung des Lesens im digitalen Kontext (pp. 101-116). Göttingen: Hogrefe.

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Current themes of research:

Reading and processing digital information, using log and process data to assess comprehension and learning processes.

Most relevant publications in the field of Psychology of Education:

Hahnel, C., Jung, A. J., & Goldhammer, F. (2023). Theory Matters: An Example of Deriving Process Indicators From Log Data to Assess Decision-Making Processes in Web Search Tasks. *European Journal of Psychological Assessment, 39*(4), 271–279. https://doi.org/10.1027/1015-5759/a000776.

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Zehner, F., & Hahnel, C. (2023). Artificial intelligence on the advance to enhance educational assessment: Scientific clickbait or genuine gamechanger? *Journal of Computer Assisted Learning, 39*(3), 695–702. https://doi.org/10.1111/jcal.12810.

Tobias Deribo. DIPF | Leibniz Institute for Research and Information in Education, Frankfurt am Main, Germany

Current themes of research:

Use of log- and process data to increase the validity of inferences based on test scores and the measurement efficiency of computer-based assessments.

Most relevant publications in the field of Psychology of Education:

Schoor, C., Zink, T., Mahlow, N., Hahnel, C., Deribo, T., Kroehne, U., Goldhammer, F., Naumann, J., & Artelt, C. (2024). Diagnostik des Leseverständnisses multipler Texte: MultiTex. [Diagnostics of reading comprehension of multiple texts: MultiTex.] In T. Richter & W. Lenhard (Eds.), Diagnose und Förderung des Lesens im digitalen Kontext (pp. 101–116). Göttingen: Hogrefe.

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Current themes of research:

Computer-based assessments, analysis, and validation of log- and process data for latent models and psychometrics.

Most relevant publications in the field of Psychology of Education:

Goldhammer, F., Kroehne, U., Hahnel, C., Naumann, J. & De Boeck, P. (2024). Does timed testing affect the interpretation of efficiency scores? A GLMM analysis of reading components. *Journal of Educational Measurement*, online first. https://doi.org/10.1111/jedm.12393.

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Current themes of research:

Technology-based assessment, innovative assessment formats, use and interpretation of process data, modelling and experimental control of response times, digital skills.

Most relevant publications in the field of Psychology of Education:

Goldhammer, F., Kroehne, U., Hahnel, C., Naumann, J. & De Boeck, P. (2024). Does timed testing affect the interpretation of efficiency scores? A GLMM analysis of reading components. *Journal of Educational Measurement*, online first. https://doi.org/10.1111/jedm.12393.

Schrickel, M., Stemmann, J., Goldhammer, F. & Hahnel, C. (2024). Assessing skills of everyday technical problem solving. *Psychological Assessment*, online first. https://doi.org/10.1027/1015-5759/a000847.

Becker, B., Weirich, S., Goldhammer, F. & Debeer, D. (2023). Controlling the speededness of assembled test forms: A generalization to the three-parameter lognormal response time model. *Journal of Educational Measurement*, online first.https://doi.org/10.1111/jedm.12364

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Current themes of research:

Competence development, in particular text comprehension, metacognition and assessments.

Most relevant publications in the field of Psychology of Education:

Karing, C., Rausch, T., & Artelt, C. (2024). Teacher judgement accuracy – measurements, causes and effects. In S. Weinert, H.-G. Roßbach, J. von Maurice, H.-P. Blossfeld, & C. Artelt (Eds.), *Educational processes, decisions, and the development of competencies from early preschool age to adolescence: Findings from the BiKS cohort panel studies* (pp. 263–280). Springer VS. https://doi.org/10.1007/978-3-658-43414-4_10.

Klose, M., Handschuh, P., Steger, D., & Artelt, C. (2024). Not easy to get off track: Motivational trajectories of learners completing a non-formal online course. *Computers in Human Behavior*, *159*, Article 108322. https://doi.org/10.1016/j.chb.2024.108322.

Pfost, M., Becker, S., & Artelt, C. (2024). Competence, motivation, and interest development between primary school and tertiary education – a summary of findings from the BiKS-8–18 study. In S. Weinert, H.-G. Roßbach, J. von Maurice, H.-P. Blossfeld, & C. Artelt (Eds.), *Educational processes, decisions, and the development of competencies from early preschool age to adolescence: Findings from the BiKS cohort panel studies* (pp. 245–262). Springer VS. https://doi.org/10.1007/978-3-658-43414-4_9.

von Maurice, J., Weinert, S., Blossfeld, H.-P., Artelt, C., & Roßbach, H.-G. (2024). The BiKS-study on "Educational Processes, Competence Development, and Formation of Educational Decisions in

Preschool and School Age": General outline of research questions and design of the BiKS-3–18 and the BiKS-8–18 studies. In S. Weinert, H.-G. Roßbach, J. von Maurice, H.-P. Blossfeld, & C. Artelt (Eds.), *Educational processes, decisions, and the development of competencies from early preschool age to adolescence: Findings from the BiKS cohort panel studies* (pp. 1–20). Springer VS. https://doi.org/10.1007/978-3-658-43414-4_1

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Current themes of research:

Reading, learning, metacognition, and educational assessment.

Most relevant publications in the field of Psychology of Education:

Goldhammer, F., Kroehne, U., Hahnel, C., Naumann, J., & De Boeck, P. (2024). Does timed testing affect the interpretation of efficiency scores?—A GLMM analysis of reading components. *Journal of Educational Measurement*. https://doi.org/10.1111/jedm.12393.

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Karageorgos, P., Richter, T., Haffmanns, M.-B., Schindler, J., & Naumann, J. (2020). The role of word-recognition accuracy in the development of word-recognition speed and reading comprehension in primary school: A longitudinal examination. *Cognitive Development*. Advance online publication. https://doi.org/10.1037/edu0000446.

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Current themes of research:

Multiple document comprehension, beliefs about science, motivation, data literacy.

Most relevant publications in the field of Psychology of Education:

Schoor, C. (2024). University students' beliefs about science and their relationship with knowledge about science. *European Journal of Psychology of Education*, *39*, 1039–1117. https://doi.org/10.1007/s10212-023-00724-2.

Schoor, C., Rouet, J.-F., & Britt, M. A. (2024). Reading for university or for myself? Effects of context and beliefs about science on college students' document selection. *Journal of Educational Psychology*, *116*(3), 317–345. https://doi.org/10.1037/edu0000849

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Schoor, C., Rouet, J.-F., Artelt, C., Mahlow, N., Hahnel, C., Kroehne, U., & Goldhammer, F. (2021). Readers' perceived task demands and their relation to multiple document comprehension strategies and outcome. *Learning and Individual Differences, 88*, 102018. https://doi.org/10.1016/j.lindif.2021.102018.

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