Advancing feedback research in educational psychology: insights into feedback processes and determinants of effectiveness

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Theoretical Analysis

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A B S T R A C T

Feedback is widely recognized as a key mechanism in educational psychology, shaping learning through cognitive, motivational, and emotional processes. Despite a rich body of research, core questions remain regarding when feedback is effective, why it works, and for whom it fosters meaningful learning. To examine the psychological and contextual mechanisms underlying feedback effectiveness, the studies included in this issue draw on diverse methodologies, including controlled experiments, longitudinal data in school settings, and log data analyses from digital learning platforms. Central themes include the role of learner characteristics in feedback reception, the emotional and motivational dimensions of feedback processing, the impact of design and delivery features, and the reciprocal dynamics between feedback providers and receivers. What emerges across these contributions is a view of feedback as a dialogic and interpretive process, embedded within broader sociocultural and instructional systems. Insights from neuroscience, digital learning environments, and achievement motivation research further advance theorizing on feedback processes and point toward new directions for empirically grounded, interdisciplinary inquiry. Building on these insights and informed by recent theoretical and empirical developments, we offer a model that conceptualizes feedback as a multilayered process—shaped by individual, contextual, and social dynamics, and unfolding across cognitive, emotional, and motivational dimensions. This model captures the complexity of feedback interactions and highlights how feedback can support learners' ongoing development, both in terms of immediate learning outcomes and longer-term academic development. We outline how such an integrative perspective and interdisciplinary collaborations are necessary for developing feedback practices that are more targeted, responsive, and impactful for lasting educational growth.

1. Introduction

Feedback is a powerful mechanism for fostering learning, shaping cognitive and motivational processes, and optimizing educational outcomes: It serves to inform learners about their current performance relative to a desired goal and provides guidance on how to bridge the gap between these states (Black & Wiliam, 2018; Hattie & Timperley, 2007; Kluger & DeNisi, 1996), aiming to influence learners' thinking or behavior to foster improvement (Panadero & Lipnevich, 2022; Sadler, 1989; Shute, 2008). Decades of research have established that feedback influences learning at cognitive, metacognitive, and motivational levels (Narciss, 2008), highlighting errors, missing knowledge, or corrections (Hattie & Timperley, 2007), supporting self-regulation by guiding goal-setting and self-assessment (Butler & Winne, 1995; Nicol & Macfarlane-

Dick, 2006; Panadero, Jönsson, et al., 2018; Winne & Hadwin, 2013), and enhancing self-efficacy, positive emotions, and persistence (Hattie & Timperley, 2007; Narciss, 2008; Wang et al., 2019). The body of literature addressing the effectiveness of feedback is vast (Wisniewski et al., 2020), with growing attention to its psychological determinants, the complexities of feedback processing, and its differential effects on diverse learners (e.g., Hattie & Timperley, 2007; Kluger & DeNisi, 1996; Narciss, 2008; Panadero & Lipnevich, 2022). For instance, feedback can enhance high-quality motivation and self-regulation, but it may also trigger disengagement or negative emotional responses, particularly when learners perceive it as threatening or unhelpful (Winstone et al., 2017). Feedback is not merely information; it is interpreted through the lens of learners' emotional and cognitive states. Therefore, research is still needed to understand why, under which circumstances, and for whom feedback is effective.

This special issue brings together cutting-edge research that advances our understanding of feedback processes and the determinants of feedback effectiveness. The included studies explore feedback across diverse educational contexts, examining individual differences in learners' responses, the role of feedback providers, and the integration of technological and pedagogical innovations. Several contributions highlight the interplay between feedback and motivation (Hübner et al., 2025; Merrick & Fyfe, 2025), providing empirical evidence on how individual learner characteristics, such as domain-specific self-concepts and anxiety, relate to feedback reception. Other studies focus on the design and delivery of feedback, demonstrating how specific features—such as emotional tone, added visual design features, elaboration, and interactivity—shape students' engagement and learning outcomes (Kuklick & Lindner, 2025; Lopera-Oquendo et al., 2025). Additionally, emerging perspectives from neuroeducational research emphasize the cognitive and affective underpinnings of feedback processing, shedding light on how learners integrate negative feedback into their learning trajectories (Kim & Shin, 2025).

Understanding how students interpret and use feedback in digital learning environments—particularly when the feedback is generated by artificial intelligence—is increasingly relevant, given the growing reliance on these environments and their potential to deliver scalable learning opportunities (Jin et al., 2025; Maier & Klotz, 2022; Nazaretsky et al., 2025). In line with current movements in the field, the studies in this special issue collectively underscore the importance of considering feedback as a dynamic and interactive process, rather than a unidirectional transmission of information (Carless, 2019). In the following sections, we introduce a comprehensive working model that synthesizes key theoretical perspectives on feedback effectiveness, integrating insights from existing frameworks while advancing a process-oriented, context-sensitive approach. We then situate the empirical contributions of this special issue within this framework, demonstrating how they address core questions related to the cognitive, motivational, and relational mechanisms underlying feedback processes alongside novel methodological advancements.

2. Integrating and advancing theoretical perspectives

Over the past decades, the feedback literature has shifted from a feedback centered perspective (Boud & Molloy, 2013a, 2013b; Handley et al., 2011; Nash & Winstone, 2017; Winstone et al., 2017), highlighting the role of feedback message and feedback characteristics (Hattie & Timperley, 2007; Shute, 2008) to a learner- and process-centered perspective (Winstone & Nash, 2023; Winstone et al., 2017). These perspectives have increasingly come together in various theoretical conceptualizations (e.g., Ajjawi & Boud, 2018; Carless & Boud, 2018; Evans, 2013; Fong & Schallert, 2023; Lipnevich & Smith, 2022) to additionally highlight the relational perspective on feedback, considering feedback as a dialogue, with its reception and effectiveness depending on the characteristics of feedback provider and feedback receiver (Price et al., 2011; Winstone et al., 2017) and their relationship

(Ajjawi & Boud, 2018) as a well as the specific feedback interaction (Carless & Boud, 2018).

Building upon this theoretical evolution, we introduce a comprehensive working model that synthesizes key research directions on feedback effectiveness. Guided by developments in the field that go beyond conceptualizing feedback as mere transmission of information (e.g., Carless, 2019; Jonsson & Panadero, 2018; Lipnevich & Smith, 2022; Panadero & Lipnevich, 2022; Winstone et al., 2017), we consider feedback as a multi-layered, dynamic process shaped by individual, relational, and contextual factors. With this model, we aim to capture the complexity of feedback mechanisms in educational settings and provide a structured framework (see Fig. 1) that can be used to integrate the contributions of the individual articles in this special issue. Specifically, integrating and extending upon previous models, we conceptualize feedback as

1. *Adaptive and multi-layered*, with responsiveness to both immediate feedback characteristics and broader achievement settings, and sociocultural influences. The REFLECT model makes this multi-layered nature explicit, delineating the feedback context, achievement context, and surrounding context in separate, interacting layers.
2. *Individually processed*, shaped by learner-specific characteristics, prior experiences, and cognitive, emotional, and motivational states. The REFLECT model highlights this by incorporating learner characteristics as a central component.
3. *Interaction-dependent*, wherein response patterns emerge dynamically from the interplay of provider-receiver interactions and ongoing feedback processing. In the REFLECT model, this is highlighted by including the provider processing as a specific part of feedback interaction in interplay with the receiver characteristics. Arrows between provider and receiver emphasize the bi-directionality and the co-regulatory potential of feedback dialogues.
4. *Developmentally relevant*, influencing long-term learning beliefs, self-regulation, and co-development of provider and receiver over time. In the REFLECT model, this developmental trajectory is embedded in the model's cyclical architecture that illustrates the longitudinal co-construction of learning and teaching processes.

Rather than replacing previous models, this framework integrates and extends them, complementing typological approaches that categorize feedback according to function and focus (Lipnevich & Panadero, 2021; Panadero & Lipnevich, 2022). In the following sections, we elaborate on the core mechanisms underpinning feedback processing, and how this refines existing perspectives.

2.1. Feedback as adaptive and multi-layered: the role of feedback context

Feedback does not occur in isolation; it is embedded within multiple layers of context that shape its interpretation and impact (Panadero & Lipnevich, 2022). More specifically, three interrelated contextual levels can be distinguished. The *immediate feedback* context includes features of the feedback itself, such as timing, accuracy, specificity, tone, and source credibility, and its effectiveness depends on how well these characteristics align with the needs and expectations of the learner (e.g., Hattie & Timperley, 2007; Kulhavy & Stock, 1989; Lipnevich et al., 2016; Lipnevich & Smith, 2022; Shute, 2008). The feedback situation is embedded within the larger *achievement context* that refers to the broader learning environment and includes task characteristics, instructional goals, and expectations (e.g., Lipnevich et al., 2016; Panadero & Lipnevich, 2022). The same feedback message may be interpreted differently depending on whether the task is perceived as challenging, meaningful, or aligned with students' personal goals, which can also depend on individual student characteristics (Lipnevich & Smith, 2022). Similarly, how feedback is interpreted can depend on both the academic domain of the task (e.g., Esterhazy et al., 2020) and how the feedback is delivered—for example, whether it occurs in a face-to-
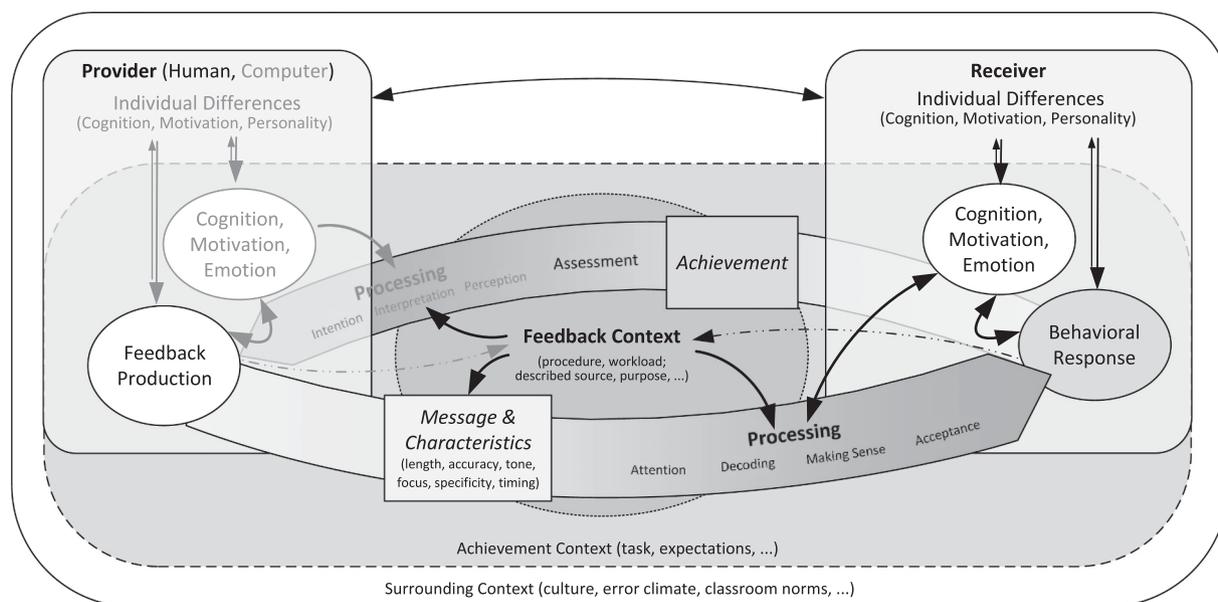
Fig. 1. *REFLECT Model of Feedback* (Reciprocal Engagement with Feedback: Learning, Emotion, Cognition, and Trajectories) conceptualizing feedback as a multi-layered, dynamic process shaped by contextual, relational, and individual factors.

face context or within a digital learning environment (e.g., Fong & Schallert, 2023; Janelli & Lipnevich, 2021; Narciss, 2008) or whether it is known to be AI-generated (Nazaretsky et al., 2024; Zhang et al., 2025). Finally, the *surrounding context* entails cultural norms, institutional policies, course specific instruction and classroom climate that influence how feedback is delivered and received (e.g., Evans, 2013; Gašević et al., 2016). For instance, in environments where errors are stigmatized, even well-intended feedback may be perceived as threatening rather than constructive (e.g., Butler, 1987; Van Dyck et al., 2005). These layers interact dynamically, meaning that feedback processing is not a static event, but an evolving process shaped by contextual influences within specific feedback situations.

2.2. Feedback as individually processed

Learners do not passively receive feedback; rather, they actively process and integrate it into their learning (Winstone et al., 2017). But not all learners perceive and engage with feedback alike: there are substantial differences between individual students (Lipnevich & Smith, 2022; Van der Kleij & Lipnevich, 2021). For example, learners with high math anxiety or low math self-concept may disengage from corrective feedback rather than using it to improve (see Merrick & Fyfe, 2024). In contrast, striving to improve and learn—often conceptualized as mastery goal pursuit (Daumiller, 2023)—along with high self-efficacy beliefs and self-regulated learning competence, has been shown to foster more positive emotional responses to feedback, increase its perceived usefulness, and promote deeper engagement with both tutorial and learning analytics feedback (Keller et al., 2024; Uzun et al., 2025). Moreover, when students act as feedback providers, their own motivation matters for how they engage in the process. Keller et al. (2025), in two field studies, found that students with high expectancy beliefs—confidence in their ability to provide helpful feedback—and those who saw the task as valuable were significantly more likely to produce high-quality peer feedback. Özbek et al. (2024) extended this line of research using path modeling with survey and log data from university computer science students. They showed that learning approach goals predicted intentions to use an online peer feedback tool, which in turn predicted actual use and final exam performance. Notably, relational goals negatively predicted both tool use and performance, likely reflecting social concerns about peer evaluation. Together, these studies highlight that both cognitive-motivational and social-motivational factors shape students' engagement in feedback processes—whether as receivers or providers.

The REFLECT model distinguishes four key stages of feedback processing, following previous theorizing (Price et al., 2011; Tärning et al., 2020; Timms et al., 2016; Winstone et al., 2017), and highlights the role of individual differences across these different stages. First, *attention:* Learners need to notice and focus on the feedback. Whether they do so depends on their cognitive factors (such as working memory capacity) and affective-motivational characteristics, including their emotional state and the perceived relevance of the task. As Timms et al. (2016) highlight, such factors critically influence whether feedback captures students' attention in the first place. Second, this is followed by *decoding* the feedback: Learners must actively read the feedback message. In addition to cognitive abilities, and motivation, students' reading and language skills also play a crucial role at this stage (Timms et al., 2016). In both of these initial stages of feedback processing, feedback characteristics such as clarity, specificity, and tone as well as social cues (Tärning et al., 2020) might influence whether feedback is noticed and decoded, and they can interact with these individual characteristics. For example, depending on students' affective-motivational state, positive or negative feedback may be more or less likely to be noticed and paid attention to.

Third, learners have to interpret and *make sense of the feedback*: Learners evaluate the feedback with regard to their motivation including their goals, self-concept and other motivational factors (see Kluger & DeNisi, 1996), as well as their cognitive abilities and domain-specific knowledge or competencies (Timms et al., 2016). Fourth, learners need to *accept* the feedback (Van der Kleij, 2019). This acceptance, and the corresponding decision to use and implement the feedback is the foundation for the *behavioral response,* in which learners decide whether the feedback is useful for their goals and whether they want to act upon it (Henderson et al., 2021; Jonsson, 2013; Kluger & DeNisi, 1996). Among others, acceptance depends on perceived credibility of the feedback, and students' motivation, and self-regulatory skills—including the ability to monitor and adjust their learning (Butler & Winne, 1995; Van der Kleij, 2019). It may also be shaped by general tendencies to react to feedback, whether individuals habitually respond defensively or constructively (e.g., Lipnevich & Panadero, 2021), and by feedback literacy, that is the capacity to interpret, evaluate, and use feedback effectively (Carless & Boud, 2018). Of note, all of these processes affect

and are shaped by learners' current cognition, motivation, emotion, and self-regulation (e.g., Kluger & DeNisi, 1996; Nicol & Macfarlane-Dick, 2006); including momentary affect, situational motivation, and cognitive load influencing real-time feedback processing. Additionally, all phases of processing can be influenced by more stable motivational dispositions, such as personality and cognitive prerequisites (Evans, 2013; Timms et al., 2016), likely related to performance outcomes in feedback situations (Meyer et al., 2025a). The degree to which individual differences—whether relatively stable traits such as personality, achievement goal orientations, or cognitive ability, or more transient states such as emotions—shape feedback processing represents an important avenue for future research. To our knowledge, this distinction has not yet been explicitly incorporated into prior theoretical models with regard to testable mechanisms.

Note that we have highlighted the behavioral implementation of feedback, as a separate phase of the feedback process. As pointed out by Tärning et al. (2020), Kluger and DeNisi (1996), and Timms et al. (2016), not all feedback processing leads to changes in behavior. Moreover, implementing feedback often depends on different individual factors than those influencing initial attention and interpretation. For example, while motivation and cognitive abilities (e.g., working memory) may shape initial feedback uptake (Timms et al., 2016), the successful application of feedback may rely more heavily on domain-specific competencies and task-related skills (Meyer et al., 2025b). Motivation can still play a vital role in whether students choose to act on feedback, but it may not be sufficient on its own.

Drawing on previous theorizing, the model further encompasses multiple outcomes of the feedback processing, including cognitive, motivational and emotional outcomes (e.g., Lipnevich & Smith, 2022). This impact of feedback is again shaped by how it is initially perceived and processed. Thus, different behavioral responses, ranging from implementing suggestions to dismissing or resisting feedback, can be expected based on this interplay of feedback processing and current learner states within the respective context. Innovative methods, such as multi-modal data that has been a focus in the learning analytics literature (e.g., Giannakos et al., 2022b; Giannakos et al., 2022a) and integrated within self-regulated learning theories (Molenaar et al., 2023) will allow novel insights into feedback processing both in and outside of digital learning environments (see Panadero, 2023).

2.3. Feedback as interaction-dependent

With the stronger shift to the learners' perspective in feedback research (Winstone & Nash, 2023; Winstone et al., 2017), a number of models predominantly focus on the receiver's role in feedback processing (e.g., Lipnevich & Smith, 2022). A few models have explicitly included the interactive relationship between feedback receiver and feedback provider (Ajjawi & Boud, 2018; Carless, 2019; Price et al., 2011; Winstone et al., 2017) as well as assumptions about not only the importance of feedback source, but also the role of certain provider characteristics (Evans, 2013; Narciss et al., 2014; Winstone et al., 2017). Here, we aimed to reiterate the importance of these aspects, considering the active role of the feedback provider as well as additional nuance on their psychological processing in the act of feedback creation and communication.

As prior research has established (Lipnevich & Smith, 2022), the (perceived) source of feedback—whether a teacher, peer, or automated system—fundamentally influences its reception and impact, which is underlined by empirical evidence on computer- or AI- generated vs. human feedback (e.g., Brummernhenrich et al., 2025; Lipnevich & Smith, 2009; Ruwe & Mayweg-Paus, 2023). Drawing on previous models focused on the computer-based context (Narciss, 2004, 2013), we emphasize that the dynamics of the feedback process differ when a computer provides the feedback. As depicted in Fig. 1, the grey-shaded components reflect elements that apply specifically to human-provided feedback and may be absent or altered when feedback is generated by an automated system.

In the model, we further focus on the processing on the part of the provider, in addition to the learners' processing. Particularly, we note that human-provided feedback involves two different processing loops. The first concerns the *assessment* of learner performance, which typically precedes the feedback process itself (Hattie & Timperley, 2007). Before giving feedback, the provider either evaluates the learner's performance themselves, drawing on cognitive, motivational, and relational considerations, or relies on information provided to them, for example, via a standardized test or computer driven assessment. This assessment process is prone to certain biases in human feedback, possibly influenced by stereotypes (Glock, 2016; Heitzmann, 2014; Südkamp et al., 2012), but can be systematically programmed in automated feedback systems (which is also not free of biases; see Baker & Hawn, 2022; Binns, 2018). Based on this information, human feedback providers engage in further cognitive processing to create a feedback message. In this process, not only does the objective information from such an assessment play a role, but individual interpretations and intentions—shaped by the providers' current states and enduring traits—can also influence what kind of feedback is given, how it is delivered, and under which circumstances. This aligns with findings by Keller et al. (2025), who showed that feedback quality of student providers is linked to motivational variables such as task value and mastery goals, suggesting that individual motivational states are not only relevant for feedback reception but also for the quality of the generated feedback. Crucially, this process can involve a double feedback loop, in that not only does the provider assess the learner, but the very act of assessment and message formulation can, in turn, affect the provider's own emotional and motivational state (e.g., disappointment, frustration, or pride), which may recursively influence how the feedback is framed.

Additionally, relational aspects (Evans, 2013) come into play. For instance, a teacher's perception of a student's potential may unconsciously affect the level of detail or encouragement included in their feedback (see Rosenthal & Jacobson, 1968). As such, feedback is embedded within interpersonal relationships characterized by trust, prior interactions, and mutual expectations. While a supportive feedback relationship fosters motivation and engagement, strained relationships may trigger defensive reactions or disengagement, and feedback in turn impacts student–teacher relationships (Skipper & Douglas, 2015). This model explicitly accounts for this by illustrating how provider-receiver interactions shape feedback processing at multiple levels. At the same time, given the increasing role of digital technologies and AI in feedback provision, the specific role of AI as feedback provider needs to be understood with regard to the feedback receiver's psychological processing, and due to the lack of social relationships in this context it can be assumed that these processes differ to a substantial degree compared to human-provided feedback (e.g., Nazaretsky et al., 2024; Zhang et al., 2025).

2.4. Feedback as developmentally relevant

Beyond immediate processing, feedback interactions have long-term developmental consequences, shaping cognitive, motivational, and behavioral trajectories. Learners not only respond to feedback in the moment but also internalize patterns of engagement that shape their broader learning trajectories. Here, we highlight two central mechanisms through which feedback exerts developmental influence.

First, *co-development of provider and receiver*: feedback is inherently relational and interactive, meaning that both learners and providers continuously shape and refine their respective roles through iterative feedback cycles (e.g., Ajjawi & Boud, 2017, 2018; Lipnevich & Smith, 2022). Learners influence the nature and quality of the feedback they receive by actively seeking, interpreting, and responding to it (Carless & Boud, 2018). Similarly, feedback providers adjust their strategies based on their experiences with learners. This interplay is particularly relevant in settings where sustained interactions between teachers and students,

or among peers, allow for ongoing calibration and refinement of feedback practices (Narciss et al., 2014). In this sense, feedback interactions constitute a bidirectional learning process, contributing to the professional development of educators and the self-regulated learning skills of students (as well as a feedback culture).

Second, *cumulative effects on learning dispositions*: feedback processing is not only influenced by individual characteristics, but feedback experiences also shape the development of these rather stable learning characteristics over time, influencing self-efficacy, learning beliefs, and feedback-seeking behaviors. Feedback experiences over time should shape learners' beliefs about their own competence, their attitudes toward learning, and their motivation to persist in challenging tasks. These long-term effects are, of course, also shaped by the surrounding context. Supportive learning environments that foster open, dialogic feedback cultures contribute to more positive experiences when receiving feedback and reinforcing adaptive motivation and self-regulation (Ajjawi & Boud, 2018). Thus, the developmental relevance of feedback extends beyond individual learners and situates it within the broader systemic and cultural influences that shape feedback experiences across educational settings (Evans, 2013).

3. Avenues in feedback research from a learner- and process-centered perspective: pathways to advancing theory, methodology, and application

In summary, addressing the complexities of feedback effectiveness requires moving beyond static conceptualizations of feedback as merely an instructional input and instead frames it as a dynamic, interactive process shaped by cognitive, motivational, and social mechanisms that influence learning (Lipnevich & Smith, 2022; Winstone & Nash, 2023). Such a learner-centered perspective highlights that the effectiveness of feedback depends not merely on its provision but on how learners engage with it—how they interpret, react to, and ultimately integrate feedback into their learning processes (Lipnevich & Smith, 2022; Winstone et al., 2017). This shift necessitates a more comprehensive understanding of the interplay between individual differences, contextual influences, and the evolving relationship between feedback providers and receivers.

Feedback is not only a cognitive tool for guiding knowledge acquisition but also a social and emotional event with profound implications for learner engagement and motivation (e.g., Bangert-Drowns et al., 1991; Fong & Schallert, 2023). Whether feedback fosters persistence and self-efficacy or triggers disengagement and defensive responses depends on various factors, including learners' prior experiences, self-beliefs, emotional states, and the perceived credibility of the provider (e.g., Kluger & DeNisi, 1996). These affective-motivational dimensions are crucial for understanding the conditions under which feedback promotes meaningful learning (Fong & Schallert, 2023; Kluger & DeNisi, 1996).

Foregrounding the learner's role in feedback processing, the reciprocal and interactive nature of feedback also became highlighted (e.g., Ajjawi & Boud, 2018; Carless, 2019; Price et al., 2011; Winstone et al., 2017). Feedback occurs within a relational dynamic between the provider and the receiver, where both influence each other in iterative cycles. The characteristics, beliefs, and intentions of feedback providers—whether teachers, peers, or digital systems—shape not only the content and structure of feedback messages but also how they are perceived and utilized.

To capture the full complexity of feedback processing and effectiveness, methodological advancements are required. Many of the most critical aspects of feedback processing—particularly those related to affective-motivational responses—are not directly observable, necessitating innovative approaches that go beyond traditional self-report measures (e.g., Bernacki, 2025; Cutumisu & Schwartz, 2018; Cutumisu et al., 2019; Tärning et al., 2020; Ternblad & Tärning, 2020). Real-time multi-modal tracking methods (Panadero, 2023), such as eye-tracking

(Tärning et al., 2020) and log data analysis (Pardo et al., 2017; Salehian Kia et al., 2023; Schiller et al., 2024), offer promising avenues for providing and studying how learners attend to and engage with feedback at the micro-level (see Panadero, 2023). Learning analytics and natural language processing can provide further insights into how feedback messages are interpreted and integrated over time as well as offer support in the feedback process (e.g., Bauer et al., 2023; Castro et al., 2023; Hutt et al., 2024). Experimental manipulations of provider-receiver dynamics (e.g., Nazaretsky et al., 2024) can shed light on causal mechanisms underlying feedback effectiveness, while large-scale longitudinal studies conducted in authentic educational settings allow for the investigation of developmental trajectories shaped by feedback experiences as well as feedback interventions (e.g., Suraworachet et al., 2023). As digital learning environments continue to evolve, educational technology also presents new opportunities for not only delivering feedback at scale (Pardo et al., 2017) but also analyzing its impact on different learner profiles (Maier & Klotz, 2022; Uzun et al., 2025). By leveraging learner data from educational technology systems, researchers and practitioners can identify patterns in how students with varying cognitive abilities, motivational dispositions, prior knowledge, or emotional tendencies respond to specific types of feedback.

Learning analytics methods that utilize data that are obtained when learners are working in educational technology environments (e.g., intelligent tutoring systems) to provide feedback are increasingly being adopted by researchers in educational psychology (e.g., Bernacki, 2025; Deininger et al., 2025), for a recent special issue in the Journal of Educational Psychology on the topic, and have a longer tradition drawing from research in the educational psychology field (Kitto et al., 2023). The literature on learning analytics can provide a rich array of methodological tools useful for educational researchers in investigating feedback processes in more detail. These include process mining to map students' feedback-related behavior over time, real-time emotion detection through facial recognition or physiological data, and the use of predictive modeling to anticipate feedback engagement based on clickstream data. Therefore, we believe it would enhance the field of educational psychology if closer connections were made to the field of learning analytics and computer science, increasing the array of methodological paradigms and technological advancements that allow detailed study of learning processes and at scale delivery of educational interventions. Methods from the field of learning analytics can help test theoretical assumptions, for example, detect whether learners with low self-efficacy are more likely to disengage from elaborated corrective feedback, or whether high-performing students consistently seek out and implement feedback more readily (e.g., Kluger & DeNisi, 1996; Lipnevich & Panadero, 2021). The analysis of log data variables and affect and behavior detection (Pardos et al., 2014), can help personalize feedback to learners' current states and thereby consider individual differences to a new degree, providing the most effective feedback possible to the learner at that moment in time. Therefore, such methodological advancements are not only essential for advancing theoretical models of feedback effectiveness, but also for generating evidence-based recommendations for optimal feedback practices in diverse contexts as well as allowing personalized feedback provision at scale. For a recent overview of research on learning analytics and feedback, see Banihashem et al. (2022).

The empirical studies included in this special issue provide starting points to how such methodological advancements can refine and expand our understanding of feedback processes. By integrating novel experimental, large-scale, and mixed-method approaches, these contributions address pressing gaps in the field, from the role of individual differences in feedback reception to the impact of contextual factors on feedback effectiveness. We hope that the research presented in this special issue can contribute to further theoretical developments in the field, foster interdisciplinary collaboration and the broadening of methodological approaches within the field of educational psychology by engaging with the literature of learning analytics and collaborating with experts from

different communities to gain more fine-grained, individualized and process-oriented perspectives on feedback effectiveness in digital learning environments and beyond, bringing together new theoretical ideas and methodological innovation.

4. The perspectives included in the special issue: overview of the included articles and emerging directions

The articles featured in this special issue collectively push the boundaries of feedback research by investigating diverse aspects of feedback effectiveness, learner engagement, and the contextual and psychological factors that shape feedback reception and processing. Table 1 illustrates the range of methodologies taken in these works, including experimental studies, large-scale longitudinal designs, data from authentic (digital) learning environments and mixed-method approaches, to provide novel insights into feedback success.

Focused on the role of individual differences in feedback processing, Merrick and Fyfe (2025) investigate elementary school students, examining the socio-emotional and behavioral outcomes of feedback in the context of mathematics within an experimental design in authentic settings. Integrating feedback and achievement motivation literature, the study explores how individual differences, such as math anxiety and self-concept, shape students' responses to feedback. Based on Kluger and DeNisi's (1996) and Grundmann et al.'s (2024) models of feedback processing, the findings provide insights into why students disengage from feedback, shedding light on feedback neglect and task abandonment and the role of students' individual differences in these processes, with a focus on affective-motivational factors. These findings underscore the importance of tailoring feedback strategies to individual learners to mitigate the risk of disengagement.

Utilizing a large data set from authentic digital learning environments, Maier and Klotz (2025) investigate the role of students' individual differences on students' feedback seeking, perceived feedback usefulness and behavioral response in a formative assessment context based on log data. Their results show that individual differences significantly shape the feedback process. Higher-performing students were more likely to seek feedback, perceive it as useful, and revise their work based on it. These findings suggest that such students are more likely to benefit from feedback opportunities while also illustrating the potential of log data to uncover patterns of behavior in authentic educational settings.

Hübner et al. (2025) investigate the long-term, reciprocal relationships between teacher feedback and students' self-concept, intrinsic value, and achievement in mathematics. By analyzing longitudinal data from a large sample of German secondary school students, the study demonstrates how students' prior experiences with feedback shape their future motivation and academic development. These insights reinforce the idea that feedback effectiveness cannot be understood in isolation but must be examined within the broader context of students' evolving learning trajectories and in the interplay with feedback providers.

Adding to this and taking a neuroeducational perspective, Kim and Shin (2025) synthesize research on the effects of negative feedback on learning and motivation. The review highlights how different types of negative feedback—such as competence-enhancing, curiosity-evoking, and self-corrective feedback—activate distinct neural and cognitive processes. The overview carves out relevant personal and contextual features that can render negative feedback most effective, especially when it aligns with mastery-oriented learning environments, reinforcing the importance of framing feedback in ways that support students' self-efficacy and engagement. On a more general note, the paper also showcases how integrating insights from educational psychology and neuroscience, just like cognitive psychology, artificial intelligence, and educational technology, is instrumental in developing a more holistic framework for understanding how feedback is processed and applied.

Another critical theme in this special issue is how learners respond to feedback from different sources and how message characteristics influence feedback uptake. To this end, Lopera-Oquendo et al. (2025) present a cross-national study on university students' emotional responses and appraisals of discrepant teacher and peer feedback. Findings reveal a general preference for teacher feedback over peer feedback, regardless of message characteristics, suggesting that credibility and authority play a crucial role in shaping feedback receptivity. However, the study also highlights variations across cultural contexts, emphasizing the need for culturally responsive feedback practices.

Regarding peer feedback, Zhang et al. (2025) examine the relationship between peer feedback characteristics, perceived helpfulness, and implementation. In a large sample of high school students, they collected peer feedback along with students' revision in response to the feedback and coded the characteristics of the feedback to analyze their relation to perceptions and uptake. Findings show that even though long feedback is generally perceived as more helpful, it is not necessarily implemented more, challenging the assumption that it is critical to increase *perceived* helpfulness of the feedback or that students should aim to implement all feedback comments they receive. Additionally, it identifies challenges related to comment overload, where an excessive number of suggestions can overwhelm feedback recipients.

Table 1
Overview of included articles.

	Topic	Theoretical perspectives	Methods	Population
Merrick & Fyfe, 2025	The role of motivation and math attitudes in feedback response	The model of motivated feedback disengagement, SEVT	Behavioral data, digital learning	Elementary school children
Hübner et al., 2025	Motivation and achievement and feedback	Hattie and Timperley model, Feedback intervention theory	longitudinal, large scale data	Lower secondary education
Grønli et al., 2025	Oral reading practices	Agentic feedback	Mixed methods, intervention pre-post study	Elementary education
Zhang et al., 2025	Perception and uptake of feedback comments according to feedback characteristics	Adapted Student-Feedback Interaction Model	Peer online feedback, text coding	High school
Kuklick & Lindner, 2025	How visual design elements matter for emotional feedback effectiveness in a computer-based context	Control-Value Theory of Achievement Emotions, Emotional Design Multimedia, Emotional Design Theory	Experimental approach	University students
Lopera-Oquendo et al., 2025	Teacher vs. peer feedback on emotional responses and feedback appraisals	Student–feedback interaction model (Lipnevich & Smith, 2022)	Multi-country study, experimental design	Tertiary education
Kim & Shin, 2025	Impact of negative feedback on learning and motivation from a neuroeducational perspective	Integrating motivation theories with neuroscience	Systematic review of neuro-educational approaches	Learners of all ages, including children, adolescents, and adult learners
Maier & Klotz, 2025	Feedback seeking, feedback usefulness and feedback behavior in a digital learning environment	Feedback as process (Winstone & Nash, 2023)	Behavioral data, authentic setting, digital learning environment	Secondary school students

The included research also emphasizes the role of feedback design, particularly in technology-enhanced learning environments. Kuklick and Lindner (2025) explore how multimedia and emotional design elements in feedback messages provided during computer-based assessments influence students' cognitive and emotional responses to feedback. The study demonstrates that adding visual elements can enhance students' emotional engagement and reduce the negative impact of corrective (i.e., negative) feedback, providing valuable insights for the design of digital feedback systems.

Beyond cognitive and emotional effects, feedback can also play a crucial role in fostering learner agency. Grønli et al. (2025) investigate how a simple checklist-based intervention can enhance teachers' feedback practices in early reading instruction. By utilizing a mixed-method approach, the study finds that when teachers receive structured guidance on providing feedback, they shift from a predominantly corrective focus to a more student-centered approach that promotes motivation and comprehension. This offers a valuable direction to practitioners and educational researchers by pointing to modest, low-cost interventions that can lead to significant changes in teachers' professional practices, considering feedback effectiveness from a contextually situated perspective.

The papers in this special issue do more than provide answers—they open new avenues of inquiry, deepening our understanding of feedback as a complex, multi-layered process. They highlight the key role of individual differences and illustrate how feedback operates within a dynamic social interaction, underscoring that feedback is not simply about the provision of information but about how it is interpreted, valued, and implemented. To this end, the included studies contribute to refining existing theories as well as offer conceptual tools and empirical insights that prompt new research designs and methodologies. Equally important, the contributions in this issue point to an evolving research agenda that goes beyond effectiveness to considering impact. Rather than focusing solely on immediate learning outcomes, future studies should investigate how feedback experiences accumulate over time, shaping students' long-term academic self-concept, resilience, and self-regulatory skills. The challenge ahead lies not only in identifying what makes feedback work but in understanding how to integrate it into learning environments in ways that foster autonomy, mastery, and lifelong learning from a context-sensitive perspective.

Taken together, these studies provide a robust and contemporary perspective on feedback research, offering a foundation for future inquiry while raising new and pressing questions. These aspects are reflected upon more comprehensively in two discussion pieces (Fong, 2025, and Koenka et al., 2025), commenting on methodological and theoretical innovations happening in the field. Fong discusses directions for future research based on the special issue papers, calling for innovative methods in feedback research as well as increased attention to social dynamics and culture in the field. Koenka et al. (2025) focus on the developmental trajectories playing a role for feedback effectiveness, especially with regard to cognitive load, and the importance of considering perspectives and needs of practitioners in feedback research. Refining our models, embracing emerging technologies, and expanding the scope of inquiry (also in interdisciplinary ways) while integrating individual and situation-specific lenses, we hope will advance the understanding of the psychological mechanisms underlying effective feedback, as well as develop feedback practices that not only enhance immediate learning outcomes but also foster long-term academic growth, resilience, and learner autonomy.

CRediT authorship contribution statement

Martin Daumiller: Writing – review & editing, Writing – original draft, Conceptualization. **Jennifer Meyer:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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