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From Perspective of Self-Determination Theory: Why Do Feedback Styles in Process Assessment Influence Learning Performance?

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Process assessment in teaching practice can enhance both student engagement and academic achievement. However, it remains unclear whether different feedback styles within process assessment influence learning performance and, if so, through which underlying mechanisms they operate. To evaluate the impact of different feedback styles in process assessment on learning performance, this study capitalized on the teaching reform of advanced mathematics at a specific engineering college and conducted a field experiment involving 178 undergraduate students. The study examines the effects and mechanisms of process assessment feedback styles (positive feedback vs. negative feedback) on learning performance from perspective of self-determination theory. Results show that positive/negative feedback based on social comparison influences learning performance through competence satisfaction, and one's mastery goal orientation moderates this relationship. These findings clarify the mediating mechanism and boundary conditions under which feedback styles influence learning performance.

Keywords: learning performance, process assessment, feedback styles, competence satisfaction, self-determination theory

INTRODUCTION

Assessment, as a critical component of the teaching process, serves as one of the most effective means to motivate students' learning motivation and performance (van der Kleij et al., 2015). Traditional course assessments predominantly rely on closed-book

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exams, written tests, and one-time summative assessments which cannot truly and effectively reflect the learning effect of students (Rakoczy et al., 2019). In 2020, the Central Committee of the Communist Party of China and the State Council issued the "Overall Plan for Deepening the Reform of Education Evaluation in the New Era," which advocates enhancing outcome evaluation, reinforcing process evaluation, and promoting comprehensive evaluation. Correspondingly, process assessment has become an inevitable trend in the reform and development of curricula and evaluation systems in China. Process assessment refers to a systematic approach that evaluates students' learning progress and performance throughout the entire course implementation (Lijun, 2024), and the primary objective is to utilize timely learning data collected from students to identify and address the challenges they have encountered in their prior learning experiences, thereby facilitating instructional adjustments that effectively improve students' learning outcomes (Schildkamp et al., 2020).The current process assessment methods encompass a wide array of formats, such as in-class questioning, in-class quizzes, course papers, class presentations, individual assignments, and group projects, thus offering a comprehensive evaluation of students' learning progress (Li & Yuan, 2023; Rakoczy et al., 2019). Existing research primarily focuses on the process assessment model and its influence on teaching effectiveness (Li & Yuan, 2023; Schildkamp et al., 2020). However, there exist diverse perspectives concerning the impact of process evaluation on learning performance (Schildkamp et al., 2020). Some studies have demonstrated that process assessment exerts a significantly positive influence on enhancing students' academic performance (Fox, 2013; Wang, 2011). For instance, research demonstrates that students in schools implementing process evaluation interventions achieve significantly higher writing proficiency than those in schools following traditional writing instruction.The findings indicate that process evaluation can significantly improve students' writing outcomes (Fox, 2013). However, several studies have also indicated that process assessment has no significant impact on learning outcomes (Fabera & Visscherb, 2018; Mangen et al., 2013; Ukobizaba & Celine, 2023). Specifically, a recent empirical study has shown that process assessment is valuable for students as it promotes active learning and collaborative engagement, yet it does not appear to significantly enhance learning performance (Ukobizaba & Celine, 2023). Furthermore, the impact of process assessment on learning performance may be influenced by various factors, including subject, educational stage, evaluation source, and feedback styles (Double et al., 2020; Li et al., 2019; van Ginkel et al., 2015; Soria et al., 2020). A meta-analysis indicates that process assessment has a relatively significant effect on the academic performance of high school and college students, whereas its positive impact is more limited in primary and secondary education. Overall, as students advance to higher educational stages, the positive influence of process assessment on academic performance exhibits a progressively increasing trend (Li et al., 2019). However, it remains unclear how the feedback styles of process assessment influence learning performance and whether individual differences exist in such effects.

Advanced Mathematics serves as a critical foundational course in engineering colleges across China.It not only provides students with essential mathematical tools required for their subsequent professional courses but also plays a significant role in developing

scientific literacy and fostering analytical and problem-solving skills.The traditional final assessment mode leads most students to believe that their regular study efforts are unimportant, as they only need to engage in last-minute cramming at the end of the term. This assessment model lacks a process-based record of students' mastery of knowledge and learning outcomes, and a single test paper is hard to cover all the knowledge points of an entire course(Li & Yuan, 2023). Therefore, in the teaching process of advanced mathematics, strengthening process assessment is crucial for enhancing students' daily learning motivation and improving overall learning outcomes (Rakoczy et al., 2019). Many universities have begun to implement process assessment in advanced mathematics, increasing the frequency of mid-term evaluations and integrating their outcomes into final grades at a predetermined ratio. Then, how effective is this process assessment that depends on multiple mid-term evaluations? It remains uncertain whether the feedback styles of process assessment influence learning outcomes and the underlying mechanisms. Therefore, this study capitalizes on the reform of advanced mathematics at a particular engineering college as an opportunity to explore, within an authentic teaching context, how feedback styles in process assessment influence learning outcomes through specific mechanisms.

CONCEPTUAL FRAMEWORK AND HYPOTHESES

The impact of process assessment feedback styles on learning performance

Grade feedback is the post-reflection information provided by teachers according to certain learning standards for students' learning performance in classroom teaching (Criss et al., 2025). The purpose is to guide students to adjust their learning objectives in time so as to improve their learning performance. Grade feedback, as a timely and direct response to academic achievement, is one of the most powerful classroom interventions currently used by teachers to promote learning and improve student motivation. However, according to the findings of meta-analyses, as much as one-third of grade-related feedback fails to enhance students' academic performance. (Wilbert et al., 2010). Therefore, investigating effective styles of grade feedback holds significant practical significance.

Feedback intervention theory posits that performance feedback can be further divided into task feedback, social comparison feedback, and individual feedback depending on the focus of the feedback (Dijk & Kluger, 2011). Social comparison feedback emphasizes the comparison results with others, and depending on its valence, it can be further categorized into positive feedback and negative feedback. Positive feedback, which is inherently comparative and carries a positive valence, has been found to increase perceived competence (Chiviacowsky et al., 2019) and alleviate concerns about ability (Lessa et al., 2018). Studies have shown that positive feedback can enhance both self-efficacy and intrinsic motivation, thereby improving learning performance (Mouratidis et al., 2008). Conversely, negative feedback, which is comparative and characterized by a negative valence, can undermine one's self-esteem and evoke negative emotions (Ilies et al., 2007). Furthermore, it can diminish an individual's attention, intrinsic motivation, and overall performance (Fong et al., 2019). Grounded in the preceding analysis, we present this hypothesis:

Hypothesis 1. Compared to the standard feedback, positive feedback will enhance

learning performance, while negative feedback will decrease learning performance.

The mediating role of competence satisfaction

Feedback assists students in identifying specific aspects of their work that require attention (Sadler, 2011). It serves both cognitive and motivational functions by initiating adaptive cognitive and behavioral responses for error correction, which are linked to both interest and future achievement (Tulis, 2013). Previous research has demonstrated that process feedback exerted a significantly greater positive indirect effect on changes in mathematics achievement and interest compared to grade-oriented feedback, mediated by its perceived usefulness (Schütze et al., 2014). Moreover, social comparison feedback has a positive influence on students' performance in statistics examinations(Delaval et al., 2015). However, the mechanisms by which social comparison feedback influences performance have received relatively little attention in previous research. Self-Determination Theory posits that individuals inherently possess three basic psychological needs: autonomy, competence, and relatedness. The fulfillment of these needs is significantly associated with intrinsic motivation and overall well-being (Deci & Ryan, 2000). Among these, autonomy refers to one 's desire to engage in activities with a sense of volition and self-determination, feeling free from external constraints and having the freedom to make choices about their actions. Competence involves experiencing a sense of efficacy and mastery in tasks, feeling capable and in control of one's work. Relatedness reflects one's aspiration to feel cared for and loved by others, as well as a sense of belonging within a group (Deci & Ryan, 2000).

Studies have demonstrated that positive feedback enhances athletes' competence satisfaction, thereby boosting their athletic achievements (Mouratidis et al., 2008). Furthermore, research indicates that both positive and negative feedback based on social comparison can influence adolescents' intrinsic motivation and behavioral persistence by affecting their competence satisfaction (De Muynck et al., 2017). Feedback grounded in social comparison sends a recognition signal, forecasting the degree of individuals' competence satisfaction and their intrinsic motivation levels (Ávila et al., 2012; Hagger et al., 2015; Van Dijk&Kluger, 2011), which subsequently affects students' learning performance (Bartholomew et al., 2018 ; Nicaise et al., 2007). In conclusion, we propose the following hypothesis:

Hypothesis 2: Positive feedback and negative feedback based on social comparison affects learning performance through competence satisfaction.

The moderating effect of mastery goal orientation

According to achievement goal theory, one's goal orientation can be categorized into performance goal orientation and mastery goal orientation (Dweck, 1986). Individuals with a mastery goal orientation prioritize the development of their abilities, focus on understanding and mastering the task, and seek to leverage their initiative during task completion. These factors collectively contribute to stimulating intrinsic motivation (Dweck, 1986). Existing research demonstrates that a mastery goal orientation can mitigate the detrimental effects of negative feedback on intrinsic motivation (Weidinger et al., 2016), reduce the anxiety induced by negative feedback in individuals, and

diminish its adverse impact on performance (Cianci et al., 2010). Therefore, we speculate that an individual's mastery goal orientation may mitigate the influence of competence satisfaction on learning performance. Correspondingly, we propose the following hypothesis:

Hypothesis 3: The impact of competence satisfaction on learning performance varies among individuals, and one's mastery goal orientation moderates this effect. Specifically, individuals with lower mastery goal orientation experience a more pronounced influence of competence satisfaction on their learning performance.

Building on the theoretical assumptions outlined previously, this study posits that the competence satisfaction serves as a mediating mechanism linking feedback styles and learning performance. Furthermore, mastery goal orientation is expected to moderate the influence of competence satisfaction on learning performance, thereby affecting the indirect pathway through which feedback styles impact learning performance via competence satisfaction. Specifically, higher levels of mastery goal orientation are hypothesized to weaken the positive relationship between competence satisfaction and learning performance, thereby reducing the magnitude of the mediated effect. Integrating these propositions, the following moderated mediation hypotheses are formulated:

Hypothesis 4: Mastery goal orientation negatively moderates the mediating effect of competence satisfaction in the relationship between feedback styles and learning performance.

In summary, to investigate the mechanisms and individual differences in the impact of grade feedback styles in process assessments on learning performance, this study sequentially tests aforementioned hypotheses through a field experiment in an educational context. Specifically, it examines the mechanisms by which feedback styles (positive feedback vs negative feedback) affects learning performance and the moderating role of one's mastery goal orientation.

METHOD

Participants

A power analysis was conducted using G*Power 3.1.9.2 to determine the required sample size prior to the initiation of the experiment. An effect size (f) of 0.4 and a significance level (α) of 0.05 were assumed, yielding a recommended minimum sample size of 130. A total of 178 undergraduate students from an engineering university in southern China were initially recruited. Participants who did not complete all mid-term exam assessments (N = 7) and those with incomplete questionnaire responses (N = 29) were excluded from further analysis, resulting in a final sample of 142 valid participants (69 females), with a mean age of 18.448 years (SD = 0.711). This sample size met the requirements determined by the power analysis.To control for the potential influence of variations in the difficulty of college entrance examination mathematics papers, all participants were selected from science students within the same province. Additionally, given that teaching style and quality can affect students' learning performance (Cianci et al., 2010; Gu et al., 2021)**,** all participants were drawn from the same instructor's class to minimize teacher-related confounding effects.

Experimental design

To enhance students' motivation for learning and comprehensively improve their academic performance, the university we selected implemented process assessment in the foundational course "Advanced Mathematics" for selected majors beginning in 2019. This initiative added five mid-term assessments. We conducted a one-semester field experiment with selected majors using process assessment for "Advanced Mathematics." A single-factor design was employed, with mid-term test score feedback styles (standard, positive, negative) as the independent variable and learning performance as the dependent variable. Learning performance was assessed based on score changes, calculated as the difference between the final exam score in advanced mathematics (capped at 100 points) and the normalized college entrance examination mathematics score. The normalization process involved converting the college entrance examination mathematics score (capped at 150 points) to a scale of 100 points using the formula: normalized score = (college entrance examination mathematics score / 150) × 100.

Experimental material

Mid-term tests

The mid-term tests, each scored out of 100 points, are designed to assess students' understanding of the content covered in each unit. A total of five tests are conducted, with each test consisting of five questions. The scores from these mid-term tests account for 30% of the final grade.

Personalized feedback materials

In collaboration with the subject teachers, we designed three feedback types based on the results of the mid-term tests: positive feedback, negative feedback, and standard feedback. Positive feedback includes both the specific test score and a positive comparison with classmates. For example: "** Student, your score for the first mid-term test is ** points. Your score is better than 60% of your classmates". Negative feedback provides the specific test score along with a negative comparison with classmates, such as: "** Student, your score for the first mid-term test is ** points. Your score is lower than **% of your classmates." Standard feedback follows the current practice of reporting mid-term test scores via excel spreadsheets. In existing experimental studies, false feedback is commonly used to manipulate perceptions of performance, with statements like "Your performance is better than 80% of participants" or "Your performance is above average" for positive feedback, and "Your performance is worse than 80% of participants" or "Your performance is below average" for negative feedback (Weidinger et al., 2016). To ensure the credibility of the feedback while accounting for potential student inquiries about each other's scores, the percentage values in the feedback materials are closely correlated with students' actual mid-term test scores. Specifically, the reported percentages are adjusted by adding 10% to the actual values. For students who scored at the highest or lowest extremes on the mid-term test, the feedback reflects their true standing, such as "Your score is better than 100% of your classmates.

Measures

Both the competence satisfaction and achievement goal oriented scales are derived from foreign literature. To ensure the accuracy and validity of the measurements, this study translated these scales into Chinese using standard forward and back-translation procedures (Brislin, 1980). The questionnaire employs a 7-point Likert scale, where 1 indicates "strongly disagree" and 7 indicates "strongly agree".

Competence satisfaction

The scale measuring competence satisfaction in the work domain(Chen et al., 2015; Schultz et al., 2015) was adopted for use in the educational context. The revised scale consists of four items, including "I am confident that I can learn this course well" and "In this class, I feel that I can achieve my expected goals." The Cronbach's α value for this scale in the present study was 0.790.

Mastery goal orientation

To measure the goal orientations of participants, we adapted the 12-item scale developed by Button (Button et al., 1996). The scale consists of six items assessing mastery goal orientation and six items evaluating performance goal orientation. A sample item for mastery goal orientation is "It is important for me to have the opportunity to do challenging work." The Cronbach's α coefficient for this scale was 0.84.

Experimental procedures

Participants were divided into three groups by class: standard feedback group (N = 55), positive feedback group (N = 47), and negative feedback group (N = 40). Each group received the corresponding performance feedback. Specifically, the standard feedback group was selected from one teaching class, while the positive and negative feedback groups were drawn from another teaching class. Both teaching classes were instructed by the same teacher.

The experiment lasted for 19 teaching weeks. Mid-term tests were conducted every three weeks, and test results were promptly provided to students after each assessment. For participants in the positive feedback group and the negative feedback group, following each mid-term test, we printed individual score sheets on A4 paper and placed them in small envelopes labeled with the student's class and name. Each class received a large envelope containing all the small envelopes, which were distributed by the course instructor through the study committee members. For the standard feedback group (i.e., the current feedback method), mid-term test results were provided via excel electronic spreadsheets.

FINDINGS

Descriptive and correlational analysis

A correlation analysis was conducted on feedback styles, competence satisfaction, mastery goal orientation, and learning performance (changes in grades). The results indicated that feedback styles were significantly correlated with competence satisfaction (r = - 0.25, p < 0.05) and learning performance (r = - 0.23, p < 0.05). Additionally,

competence satisfaction was positively correlated with learning performance (r = 0.32, p < 0.01), and mastery goal orientation was also positively correlated with learning performance (r = 0.27, p < 0.05).

Statistical testing of hypotheses

A comparison of learning performance among the three groups

One-way ANOVA showed that the feedback styles of midterm test results would significantly affect students' learning performance (grade change), F (2, 139) = 6.30, p < 0.01. Further pairwise comparisons revealed that the learning performance of the positive feedback group (M = 12.76, SD = 17.22, N = 47) was significantly higher than that of both the negative feedback group (M = 4.54, SD = 18.53, N = 40; t(85) = 2.14, p = 0.04, Cohen's d = 0.460) and the standard feedback group (M = 1.22, SD = 14.55, N = 55; t(100) = 3.67, p < 0.001, Cohen's d = 0.72). Specifically, the positive feedback group demonstrated the highest learning performance among the three groups. In addition, there was no difference in learning performance between the negative feedback group and the standard feedback group (t (93) = 0.98, p = 0.332, Cohen's d = 0.20). Therefore, part of Hypothesis1 is supported.

Test of main effects

As indicated in Table 1, we put control variables and feedback style as the independent variables in Model 1, the regression data revealed that feedback styles exerted a substantial negative influence on learning performance (c = -8.19, SE = 3.87, p < 0.05) . This conclusion provides data support for the subsequent analysis.

Mediating effects test

As presented in Table 1, the mediating effect was assessed using the stepwise regression method. In this analysis, feedback styles served as the independent variable, learning performance was the dependent variable. Additionally, gender and age education were controlled for as potential confounding factors. Model 2 shows that feedback styles is significantly positively related to competence satisfaction (a = - 0.50, SE = 0.22, p < 0.05). Model 3 demonstrates that when both feedback styles and competence satisfaction were included in the regression model, feedback styles did not significantly predict learning performance (c' = -5.58, SE = 3.83, p = 0.15), whereas competence satisfaction significantly predicted learning performance (b = 5.28, SE = 1.88, p < 0.01). This suggests that competence satisfaction fully mediate the relationship between feedback styles and learning performance.

By conducting a more precise Bootstrap test for the mediation effect (with 5,000 resamples), the 95% confidence interval of the indirect effect does not include zero, thus confirming the statistical significance of the result. The results of the analysis indicate that competence satisfaction significantly mediates the relationship between feedback styles and learning performance (β = -2.62, Boot SE =1.39, 95% CI [-5.65, -0.18]). Thus, Hypothesis 2 is supported.

Moderating effects test

The independent variable (competence satisfaction) and the moderating variable (mastery goal orientation) were mean-centered to enhance statistical robustness.

Subsequently, a stepwise regression analysis was conducted to examine the moderating effects. As shown in Model 4 of Table 1, the interaction term between competence satisfaction and mastery goal orientation had a statistically significant negative effect on learning performance (b = -5.43, SE = 2.11, p < 0.01). Therefore, Hypothesis 3 is supported.

To further elucidate the interaction dynamics between competence satisfaction and mastery goal orientation, participants were divided into two groups—high mastery goal orientation and low mastery goal orientation—based on one standard deviation above and below the mean. A simple slope analysis was then performed, and the results were visualized in an effects analysis chart (Fig. 1). The findings indicated that for the low mastery goal orientation group, competence satisfaction significantly and positively predicted learning performance (B_{simple} = 7.83, t =3.38, p < 0.01). Conversely, for the high mastery goal orientation group, competence satisfaction did not significantly predict learning performance (p = 0.73). These findings indicate that mastery goal orientation negatively moderates the relationship between competence satisfaction and learning performance, thereby offering additional support for Hypothesis 3.

Table 1
The moderated mediating effect test of feedback styles on learning performance

Variables	Model 1			Model 2			Model 3			Model 4		
	Dependent variable: learning performance			Dependent variable: competence satisfaction			Dependent variable: learning performance			Dependent variable: learning performance		
	SE	*β*	*t*	*SE*	*β*	*t*	*SE*	*β*	*t*	*SE*	*β*	*t*
Gender	4.06	- 0.58	- 0.14	0.23	- 0.34	- 1.48	3.95	1.19	0.30	3.80	- 0.09	- 0.02
Age	2.72	- 2.32	- 0.85	0.15	0.14	0.94	2.63	-3.08	-1.17	2.54	- 2.07	- 0.82
Feedback styles	3.87	- 8.19*	- 2.12	0.22	- 0.50*	- 2.29	3.83	-5.58	-1.46	3.68	- 4.63	- 1.26
Competence satisfaction							1.88	5.28**	2.81	1.91	3.43	1.79
Mastery goal orientation										2.34	5.02*	2.14
Competence satisfaction × mastery goal orientation										2.11	-5.43*	-2.57
R^2		0.060			0.09			014			0.24	
F		1.76			2.85*			3.40*			4.10**	

Note. N = 87. Unstandardized regression coefficients are reported. * p < 0.05, **p < 0.01, *** p < 0.001.

Moderated mediation effects test

Following the methodology proposed by Preacher, Rucker, and Hayes (2007), this study conducted a test to examine the significance of the moderated mediation effect model. Results showed that for college students with a higher mastery goal orientation (one standard deviation above the mean), the indirect effect of feedback style on learning performance through competence satisfaction is not statistically significant (b = 0.49, Boot SE = 1.43, CI = [-2.38, 3.72]). In contrast, for students with a lower mastery goal orientation (one standard deviation below the mean), this indirect effect is statistically

significant (b = - 3.88, Boot SE = 2.17, CI = [- 8.63, - 0.29]). These findings indicate that higher levels of mastery goal orientation weaken the indirect relationship between feedback styles and learning performance via competence statisfaction, and vice versa. Thus, the data provide empirical support for Hypothesis 4.

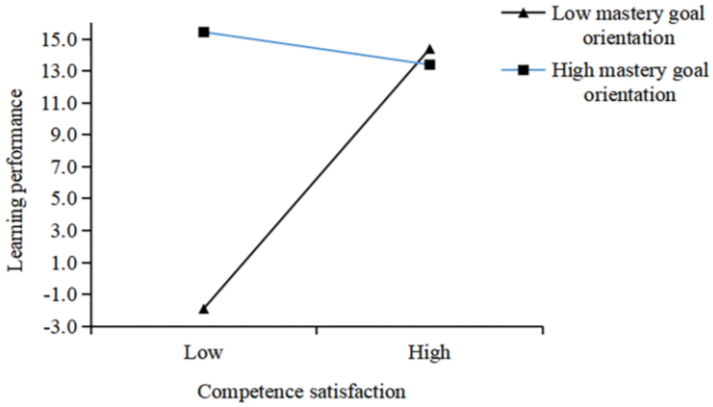

Figure 1
The interaction between competence satisfaction and mastery goal orientation on learning performance

DISCUSSION

This study examined the impact of feedback styles in process assessment on learning performance through a field experiment. The results indicate that, firstly, feedback styles significantly influence students' learning performance. Specifically, positive feedback enhances academic performance. However, contrary to Hypothesis 1, there was no significant difference in learning performance between the negative feedback group and the standard feedback group. This may be attributed to the fact that negative feedback in our study was provided privately and individually. Meta-analyses have shown that providing negative feedback privately can mitigate its adverse effects on learning performance (Fong et al., 2019). Secondly, consistent with Hypothesis 2, positive feedback and negative feedback based on social comparison affect students' learning performance through competence satisfaction. Thirdly, one's mastery goal orientation moderates the effect of competence satisfaction on learning performance. Specifically, for students with lower mastery goal orientation, the impact of competence satisfaction on learning performance is more pronounced, supporting Hypothesis 3. This study leverages the reform of advanced mathematics at a specific engineering college to investigate the mechanisms and individual differences in how feedback styles in process assessment (positive feedback vs negative feedback) influence learning performance within a real teaching context, thereby contributing to both theoretical understanding and practical applications.

Theoretical implications

First, this study extends the research on the impact of process assessment. Prior studies have primarily focused on the concept, current status, and effects of process assessment

on learning engagement and motivation (Lijun, 2024; Rakoczy et al., 2019; Li & Yuan, 2023). However, limited attention has been given to how different feedback styles in process assessment influence student performance. Consistent with previous findings (Wilbert et al., 2010), our results show that positive feedback can enhance students' academic performance. This study, based on a field experiment, is the first to empirically verify the impact of feedback styles in process assessment on learning performance, thereby addressing the academic community's call for more research on the influence and mechanisms of process assessment (Rakoczy et al., 2019).

Second, this study elucidates the "black box" of how positive feedback and negative feedback based on social comparison influence learning performance. Previous studies have primarily focused on the mediating roles of positive emotions and learning motivation in the relationship between feedback styles and student grades(Lewthwaite, 2016; Rakoczy et al., 2019). However, from the perspective of self-determination theory, this study uncovers the underlying mechanisms through which feedback styles in process assessment enhance learning performance. Consistent with prior research (Mabbe et al., 2018; Mouratidis et al., 2008), our findings indicate that feedback styles based on social comparison affects students' competence satisfaction, which in turn influences learning performance. This effect may be attributed to the fact that social comparison-based feedback conveys a message of recognition, thereby enhancing individuals' competence satisfaction and intrinsic motivation (Ávila et al., 2012; Hagger et al., 2015), ultimately promoting learning. This study deepens the understanding of the mechanisms through which feedback styles impact learning performance and extends empirical research integrating self-determination theory, feedback styles, and learning outcomes.

Third, this study sheds light on individual differences in how feedback styles influence learning performance. Prior research has predominantly focused on the effects of positive and negative feedback on students' learning motivation and performance (Chiviacowsky & Drews, 2014; Martinez et al., 2024), with less attention to boundary conditions. This study examines the moderating role of mastery goal orientation and reveals that for individuals with lower mastery goal orientation, the impact of feedback styles on learning performance via competence satisfaction is more pronounced. These findings delineate the boundary conditions under which feedback styles affect learning performance.

Practical implications

This study has significant practical implications for improving process assessment, enhancing its effectiveness, and promoting learning performance through individualized teaching strategies. The findings demonstrate that feedback styles in process assessment substantially influence students' learning performance in advanced mathematics, with positive feedback being especially effective in enhancing student performance. Therefore, in the teaching of mathematics and other science subjects at both universities and junior high schools, the traditional instructional model that emphasizes examinations while neglecting feedback should be replaced with a positive feedback-oriented approach grounded in process assessment. Additionally, the study reveals that an individual's mastery goal orientation weakens the relationship between feedback

styles and learning performance. During the learning process, negative feedback is inevitable. Consequently, it is crucial to foster students' mastery goal orientation to mitigate the adverse effects of negative feedback and other negative experiences on academic performance.

Limitation and future directions

Due to limitations in time and resources, this study has certain limitations. First, this study examined the impact of different forms of performance feedback (positive feedback vs. negative feedback) on learning performance. However, the source of feedback is a critical factor influencing its effectiveness（Trang & Anh, 2022）. Future research should explore the interaction between feedback styles and source to further refine and expand the understanding of process assessment. Second, recent studies consistently suggest that process-oriented feedback, which integrates task feedback, process feedback, and self-regulation feedback, is more effective in enhancing student learning performance compared to feedback based on social comparison (Schultz et al., 2015). Process-oriented feedback emphasizes collecting data on students' learning progress and using it to adjust their thinking or behavior to improve learning outcomes, such as comparing students' performance longitudinally and identifying specific reasons for incorrect answers along with improvement measures (Rakoczy et al., 2019; Patra et al., 2022). Future research could leverage big data to investigate how process-oriented feedback can be used to enhance process assessment and thereby boost learning performance.

CONCLUSIONS

Drawing on self-determination theory, our findings demonstrate that process assessment feedback styles (i.e., positive versus negative feedback) affect learning performance via the mediating role of competence satisfaction. Additionally, an individual's mastery goal orientation moderates this relationship, such that for students with a lower mastery goal orientation, the impact of competence satisfaction on learning performance is more pronounced. Consequently, this study enriches the existing literature by providing deeper theoretical insights into the mechanisms underlying the positive outcomes of process assessment.

ETHICS STATEMENT

This study was reviewed and authorized by the local institutional review board. All subjects provided written informed consent before the formal survey.

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