PERFORMANCE FEEDBACK, EXERCISE ENGAGEMENT, AND DROPOUT INTENTION IN UNIVERSITY MATHEMATICS

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High dropout rates in mathematics-intensive study programmes remain a persistent challenge in higher education. This study investigates how students' dropout intentions are shaped by the interplay between performance feedback and engagement in exercise tutorials. Using a longitudinal design, data of 125 students in mathematics-intensive study programmes were analysed using linear mixed models. Findings reveal that performance feedback from a midterm exam acts as a critical calibration point, triggering a divergence in students' dropout intentions. Especially for students with lower exercise engagement, midterm performance feedback is critical for dropout intention. In contrast, students with high exercise engagement tend to be less reactive to exam results. However, this immunity comes at a cost that is discussed.

INTRODUCTION

Student dropout in mathematics-intensive study programs represents a significant challenge for higher education systems worldwide (Di Martino et al., 2023; Oliveira et al., 2025). While international studies report general dropout rates between 25% and 45%, dropout rates in mathematics can reach as high as 80% (Bäulke et al., 2022; Geisler et al., 2023). Approximately half of these instances occur during the first year of study, a phenomenon known as early dropout (Geisler et al., 2023; Oliveira et al., 2025). This high attrition rate is largely attributed to the transition from secondary to tertiary education in mathematics, often experienced as a mathematical "culture shock" (Burazin & Lovric, 2018) that can overwhelm even students who were considered high achievers in secondary school (Di Martino & Gregorio, 2019; Gueudet, 2008).

A critical factor of dropout intentions is the performance feedback students receive, particularly from exams in "gatekeeper" courses, which are often mathematics lectures (Dibbs, 2019; Oliveira et al., 2025). A poor grade in such courses can be a shock, causing cognitive dissonance and leading students to reevaluate their identity and suitability for the subject (Oliveira et al., 2025; Pleskac et al., 2011). Most studies have relied on data from the final exams. However, evidence shows that many mathematics dropouts do not even attend these exams (Geisler et al., 2023). Consequently, final exams often cannot capture the early stages of withdrawal, necessitating a focus on in-semester performance measures as more sensitive diagnostic indicators of person-environment fit. Therefore, the present study analyses the effects of exercise engagement, exercise presentations, and midterm performance feedback on students' dropout intention. The subsequent sections present the theoretical framework of the study, followed by the methods, results, and discussion of the empirical study.

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THEORY

Dropout intention as a process

As actual dropout is often difficult to track, many studies utilise dropout intention as an empirically validated indicator of potential attrition (Findeisen et al., 2024). Contemporary research defines dropout intention not as a spontaneous event but as a longer-lasting, multi-staged decision-making process (Bäulke et al., 2022; Findeisen et al., 2024). This process typically progresses through distinct cognitive stages: the initial sensing of a non-fit, unsystematic thoughts of quitting, a conscious deliberation between remaining and alternatives, a targeted search for information, and finally, the implementation of a decision (Bäulke et al., 2022). While these phases are theoretically established, there is a lack of quantitative evidence on how specific performance signals accelerate or stall movement between these phases over time.

Performance feedback and engagement

Two pivotal factors influencing this process are performance feedback and student engagement. Performance feedback informs students whether their abilities meet the university's demands (Findeisen et al., 2024; Geisler et al., 2023). Negative performance feedback significantly predicts dropout (Geisler et al., 2023). This impact is often moderated by the student's "success theories" (Di Martino & Gregorio, 2019): If mathematical ability is seen as an innate talent, failure is likely to be seen as a sign of personal inadequacy, leading to resignation. Furthermore, while empirical studies have often found gender-specific patterns in study dropout, recent longitudinal studies suggest that these gaps are narrowing (Kwiek & Szymula, 2025), indicating a shift in attrition patterns that requires updated empirical tracking.

Engagement is primarily described by regularity (e.g., the consistent completion of weekly exercises) and persistence (the determination to continue despite difficulties; Büchele, 2023). Engagement acts as a mediator between learning strategies and actual performance (Büchele, 2023) and seems to enable students to better regulate the unpleasant emotions characterising the transition to university mathematics (Di Martino et al., 2023; Dibbs, 2019). Thus, the interaction between the effort a student invests (engagement) and the resulting evaluative signals (feedback) may determine the temporal development of dropout intentions (Oliveira et al., 2025).

However, we still lack a comprehensive understanding of how the interplay between individual engagement and performance feedback drives changes in dropout intentions. To examine these dynamics, we pose the following research questions:

- RQ1: How do different performance measures relate to students' dropout intentions?
- RQ2: How does midterm performance feedback moderate the temporal development of dropout intentions, and are there gender-specific trajectories?
- RQ3: How do exercise engagement and midterm performance feedback interact over time to predict changes in dropout intentions?

METHODS

Study design and sample

This study employed a longitudinal design to track students' dropout intentions at the midpoint (T1, one week before midterms) and at the end (T2) of the semester. The data were collected during three different mathematics lectures that covered topics in stochastics and business-related mathematics. Course assessments were cumulative, comprising a midterm (30%), a final examination (50%), and continuous assessment through exercise engagement. Each week, students indicated which of the exercise tasks they had prepared (10%). From the students who prepared a specific task, one was randomly selected to present the solution on the blackboard, which was evaluated based on mathematical reasoning and the quality of the presentation (10%).

The sample consisted of students enrolled in different mathematics-intensive study programmes at an Austrian university. The data comprised a total of 183 observations, involving N = 125 individual participants, of whom 107 (61 female, 46 male) participated at T1, and 76 (31 female, 45 male) at T2. Participants were enrolled in diverse study programmes: International Business and Economics (n_{T1} = 37, n_{T2} = 37); Applied Informatics (n_{T1} = 30, n_{T2} = 17); Robotics and Artificial Intelligence (n_{T1} = 17, n_{T2} = 6); Mathematics Teacher Education (n_{T1} = 12, n_{T2} = 9); Technical Mathematics (n_{T1} = 5, n_{T2} = 4); and Management, Economics & Data Sciences (n_{T1} = 3, n_{T2} = 3).

Measures

At T1 and T2, participants completed a paper-based questionnaire that included four items capturing dropout intention (e.g., "I'm considering quitting my studies" or "it occurs to me that my study program does not suit me well"; Cronbach's α = .71, McDonald's ω = .73; Bäulke et al., 2022) on a 6-point Likert scale. Participants indicated their gender and provided informed consent, allowing their data to be matched with their course assessment data and used for scientific analyses.

To account for the specific requirements of the different courses, exercise and presentation scores were z-standardised within each specific course, reflecting a student's relative effort compared to their immediate peer group. Midterm results were z-standardised across the entire sample to capture the impact of absolute performance feedback, as students typically perceive their exam grades as an indicator of their overall academic standing rather than a relative measure within their specific course.

Statistical Analysis

A linear mixed model was employed in Jamovi to analyse the change in dropout intention between T1 and T2, accounting for nested observations. The analysis followed a hierarchical, step-by-step procedure. The baseline model indicated high individual differences (Intra-Class Correlation (ICC) = .62) but very low study programme differences (ICC = .00). Consequently, the random intercept for study programme was dropped in all subsequent models for model parsimony.

Building on this, three models were built: Model 1 established the longitudinal structure with time, gender, midterm performance, prepared exercise tasks, and presentation evaluations as fixed effects to analyse their independent main effects on dropout intention (RQ1). Model 2 added the time-gender and time-midterm interactions to test whether the gender-specific trajectory of dropout intention changes over time and, crucially, how midterm performance feedback moderates the temporal development of dropout intention from T1 to T2 (RQ2). Model 3 added all time-midterm-exercises interactions to analyse the change in dropout intention over time based on the interplay of midterm performance and exercise engagement (RQ3).

RESULTS

Table 1 shows the linear mixed model results. The Marginal R^2 values indicate that the inclusion of the predictors improved the models' explanatory power, although most variance in dropout intention remains attributable to stable inter-individual differences.

Table 1: Results of the linear mixed model analyses
(Given are standardised estimates β. $^{\#}p < .10$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.
Time: T2 compared to T1; Female: Female gender compared to male)

Predictor	Modell 0	Modell 1	Modell 2	Modell 3
(Intercept)	1.62^{***}	1.61^{***}	1.59^{***}	1.52^{***}
Time		0.09	0.07	0.01
Female		$-0.22^{\#}$	-0.25^{*}	$-0.21^{\#}$
Midterm Exam		-0.09	$-0.11^{\#}$	$-0.11^{\#}$
Exercises		0.03	0.03	$0.13^{\#}$
Presentation		$-0.14^{\#}$	$-0.14^{\#}$	$-0.13^{\#}$
Time × Female			$-0.26^{\#}$	$-0.24^{\#}$
Time × Midterm			-0.18^{*}	-0.25^{***}
Midterm × Exercises				0.18^{**}
Time × Exercises				0.20^{*}
Time × Midterm × Exercises				$0.13^{\#}$
Marginal R^2	.00	.09	.11	.16
Conditional R^2	.62	.64	.69	.73
ICC (Person)	.62	.61	.65	.68

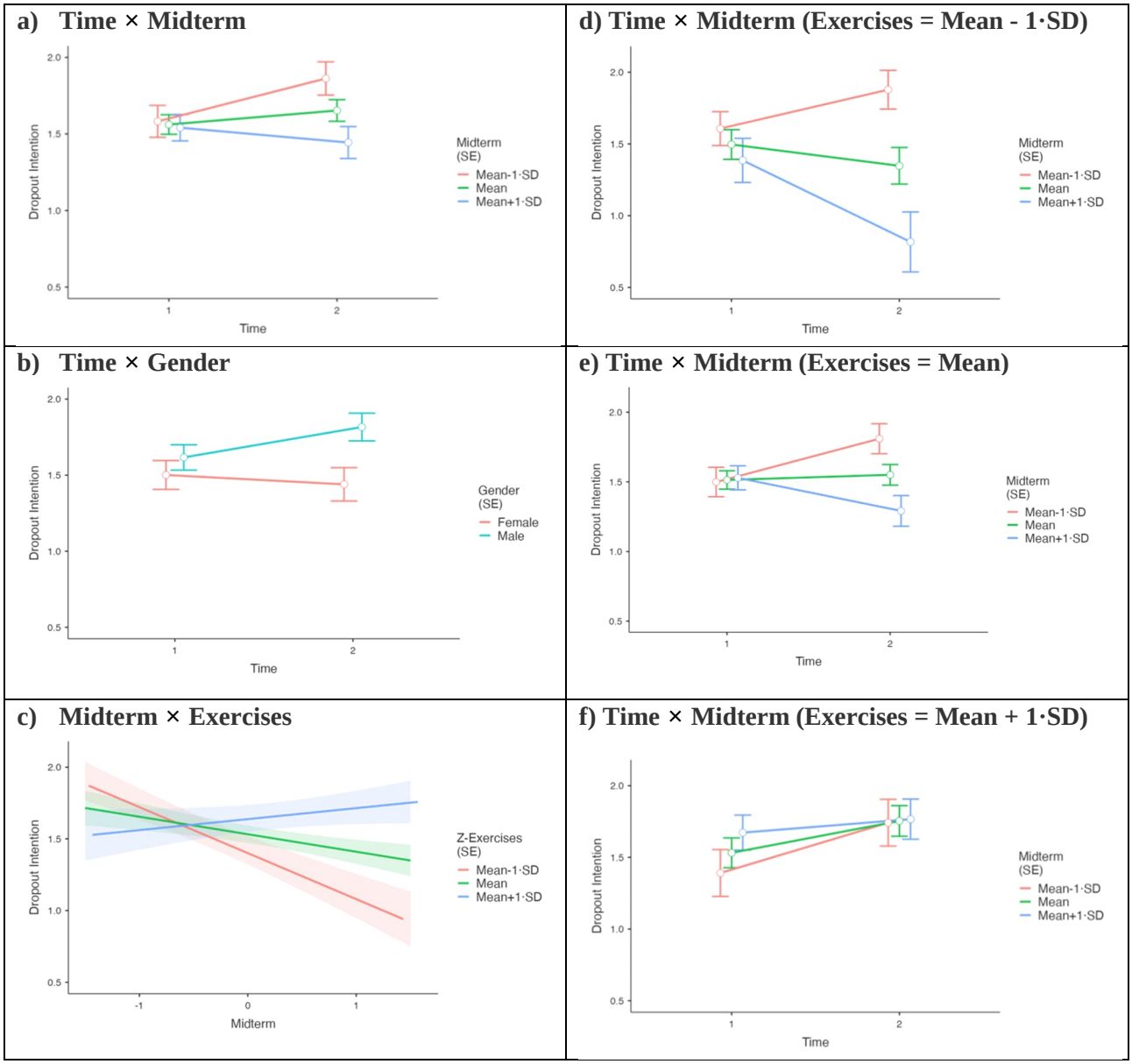
Differential impact of performance measures (RQ1)

Presentation performance was consistently negatively associated with dropout intention ($\beta = -0.14$, $p = .053$), suggesting that the ability to present well may serve as an early protective factor against dropout. In contrast, the midterm exam and exercise preparation did not show significant main effects at this stage (cf. Table 1, Model 1).

Midterm performance feedback and gender trajectories (RQ2)

Regarding RQ2, the results for Model 2 showed a significant time-midterm interaction ($\beta = -0.18$, $p = .013$), which intensified in Model 3 ($\beta = -0.25$, $p < .001$). This effect is visualised in Figure 1a, showing how dropout intention increased after comparatively poor midterm results (red line) and decreased after positive midterm feedback (blue line).

Figure 1: Visualisations of the interaction effects



Furthermore, female students generally reported lower dropout intentions ($\beta = -0.25$, $p = .036$). The marginal time-female interaction ($\beta = -0.26$, $p = .062$) suggests that while male students' dropout intentions tended to increase following the midterm exam, female students exhibited higher motivational stability over time. This effect is visualised in Figure 1b.

The interplay of exercise engagement and midterm feedback (RQ3)

Regarding RQ3, the results for Model 3 showed a significant two-way interaction between exercise preparation and midterm performance ($\beta = 0.18$, $p = .001$), indicating that the relationship between exercise engagement and dropout intention is fundamentally contingent upon performance success. Figure 1c indicates that students with lower exercise scores responded more sensitively to midterm exam feedback, while the dropout intention of students with higher exercise scores was rather stable. This is supported by the marginal three-way time-midterm-exercises interaction ($\beta = 0.13$, $p = .093$). Figure 1d illustrates how the dropout intention of students with lower exercise scores spreads out after the midterm exam, in response to the respective feedback, while Figure 1f illustrates the stability in dropout intention of students with higher exercise scores.

DISCUSSION

The diagnostic value of in-semester performance (RQ1)

Our findings underscore the role of in-semester performance measures for dropout intention. Compulsory exercise tasks and presentations serve as gatekeeper metrics, providing the first tangible signal of person-environment fit (Geisler et al., 2023; Oliveira et al., 2025). These metrics are not merely a measure of cognitive ability but may serve as a proxy for a student's ability to navigate the culture shock and the rigorous deductive reasoning required by university mathematics (Burazin & Lovric, 2018; Di Martino & Gregorio, 2019; Gueudet, 2008).

Temporal dynamics of dropout intentions and performance feedback (RQ2)

In line with theoretical considerations, our results suggest that the midterm informs students whether their abilities meet the university's demands and thereby influences dropout intentions (Geisler et al., 2023; Oliveira et al., 2025; Pleskac et al., 2011). The results indicate that for low-achieving students, this feedback triggers a significant re-evaluation of their commitment, whereas high-achieving students experience a stabilisation or decline of dropout intentions. This performance feedback from the midterm is complemented by the performance feedback from the presentations, which consistently served as a protective factor against dropout intention across all models.

Regarding gender-specific trajectories, our data aligns with recent research suggesting that the attrition gap between men and women is narrowing (Kwiek & Szymula, 2025). While historically women in mathematics-intensive study programs have shown higher withdrawal rates (Kwiek & Szymula, 2025), women in our sample exhibited

significantly lower dropout intentions and more favourable trajectories compared to their male counterparts (cf. Figure 1b).

The moderating role of exercise engagement (RQ3)

While Model 1 shows that exercise points alone have almost no direct effect on dropout intentions, Model 3 indicates they are vital when viewed as a moderator. For students with low exercise engagement, the midterm result appears to act as a precipitating event that forces a re-evaluation of persistence (Pleskac et al., 2011). A poor midterm result led to the highest dropout intentions in the sample.

In contrast, for students with high exercise engagement, dropout intentions remained relatively stable regardless of their grade. These students likely perceive success as being tied to controllable factors like effort, which mitigates the impact of a single external evaluation (Dibbs, 2019). However, these findings also reveal that students with high exercise engagement and good midterm exam results reported higher dropout intentions than those who achieved success with lower investment. This suggests that for high performers, the perceived burden of maintaining such intensity may lead to a critical re-evaluation of the effort-to-reward ratio, potentially driving exhaustion or negative emotions (Di Martino & Gregorio, 2019).

Limitations and implications

The interpretation of these findings requires caution, as this study has limitations inherent to its design. It relies on a single Austrian university and a relatively small sample size ($N = 125$), limiting generalizability. While participant attrition between T1 and T2 may introduce survival bias, the use of linear mixed models helps mitigate this risk by utilising maximum likelihood estimation to incorporate all available data points, providing more robust estimates even when data is missing. Finally, the study relies on self-reported dropout intentions that may be subject to social desirability bias but serve as a proven proxy for actual dropout (Findeisen et al., 2024).

Nonetheless, the synthesis of these findings supports that preventing dropout requires interventions that address both cognitive and affective needs (Di Martino et al., 2023). Mathematics learning support centres can facilitate collaborative learning and prevent passive resource exchange (Gildehaus et al., 2025). Furthermore, the design of exercises and their alignment with midterms appear to be key factors in helping students calibrate their expectations before facing high-stakes feedback, thereby fostering students' mathematical self-concept and a more stable person-environment fit (Geisler et al., 2023; Oliveira et al., 2025). However, the underlying specific interplay of this alignment requires closer examination in future studies.

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