Addendum to pre-analysis plan

Title of Study: Students' knowledge, performance, and satisfaction
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Table of Contents

1. Motivation for addendum

Following the initial round of data collection, preliminary analysis, and feedback received during internal presentations and external review (including journal submissions), we have identified the need to extend the scope of our data analysis to better understand the behavioral mechanisms underlying our intervention.

While the original pre-analysis plan focused primarily on economic outcomes and variables collected during the survey, the intervention appears to have generated nuanced behavioral and psychological responses that are not fully captured by our pre-specified variables or hypotheses. As such, we propose to broaden our analytical focus by incorporating insights from behavioral and cognitive psychology, allowing us to explore mechanisms with greater depth and theoretical clarity.

This addendum outlines and justifies the proposed extensions to our analysis. Importantly, all proposed additions are based solely on existing data; no new data collection is planned at this stage.

2. Expansion of theoretical framework

We will enrich the theoretical framework of our study by explicitly incorporating concepts from behavioral economics and cognitive psychology, with a primary emphasis on the planning fallacy as a key behavioral mechanism potentially driving our observed treatment effects: The planning fallacy refers to individuals' systematic tendency to underestimate the time, costs, or resources needed to complete future tasks, even when they have prior experience with similar tasks (Kahneman & Tversky, 1979). This bias arises from an over-reliance on idealized scenarios and a neglect of past performance or potential obstacles.

While our original pre-analysis plan touched on temporal distortions and overconfidence in planning, we did not explicitly frame this as a case of the planning fallacy. We now recognize this as a central and theoretically grounded explanation for the behavioral patterns we observe, particularly in relation to time management, task follow-through, and goal completion. We will therefore revisit our data analysis with an eye towards this potential mechanism.

While the planning fallacy is our primary behavioral mechanism of interest, we also explore two closely related cognitive biases, namely optimism bias and the Dunning-Kruger effect. Optimism bias is the general tendency to overestimate the likelihood of positive events and underestimate the likelihood of negative events in one's future. Optimism bias can reinforce the planning fallacy by leading individuals to ignore potential barriers or overestimate their own ability to execute a plan. The Dunning-Kruger effect refers to the tendency of individuals with lower ability in a domain to overestimate their competence. In our context, this may manifest in inaccurate self-assessments related to planning, execution, or behavioral regulation, especially among low-performing participants who may be unaware of their performance gaps.

These biases are not mutually exclusive and may interact to amplify poor planning or miscalibration in behavior. Where feasible, we will explore evidence consistent with these biases in the Moodle data, using the new variables introduced below.

3. Description of new variables

This section links the mechanisms we aim to investigate to newly constructed variables derived from the Moodle data. Each mechanism is followed by a list of variables that serve as proxies for it, along with brief descriptions and coding intentions.

1. **Planning Fallacy**

The planning fallacy refers to the systematic underestimation of the time, effort, or resources required to complete future tasks, even when individuals have relevant past experience. It often leads to overly optimistic plans, procrastination, and last-minute compensatory behavior. We plan to create the following variables:

- Consecutive active weeks (maximum number of consecutive weeks with any engagement; from Tuesday to Tuesday; with and without winter break): Longer streaks suggest better long-term planning and consistency.
- Relative engagement rate (active weeks divided by total number of weeks until the exam): Indicates how regularly students engage with the material over time.

- Number of inactive weeks (Total number of completely inactive weeks; from Tuesday to Tuesday): Larger numbers of inactive weeks may signal failure to plan or maintain discipline.
- Standard deviation of time between activities: Larger value indicates higher inconsistency of online activity and thus signals an irregular engagement
- Number of Activities in the last week before the exam (number of logins in the 7 or 10 days prior to the exam): High values suggest last-minute cramming, possibly due to misjudged planning.
- Night sessions before the exam (Number of days in the final week before the exam with activity between 22:00 and 06:00): May reflect emergency efforts to compensate for earlier inactivity.
- Delay between lecture end and first login on Moodle (Time (in minutes) between end of lecture and first login that week): A growing delay over the semester may indicate deteriorating planning or engagement
- Download of problem sets without immediate download of solutions (Binary indicator for downloading a problem set >30 minutes before its solution): Deliberate engagement suggests better planning; skipping directly to the solution may indicate shortcuts.
- Weekly engagement variability (coefficient of variation of weekly engagement time (std. dev. / mean), calculated from week 4 and week 8 onwards): High variability may signal erratic work habits; low variability rather signals consistent planning.

2. **Optimism Bias**

Optimism bias is the cognitive bias that causes individuals to overestimate the likelihood of positive outcomes and underestimate risks or challenges. In learning contexts, this might lead to unrealistic expectations about how much effort is needed. We plan to create the following variables:

- Participation in online tutorials (proportion of completed tutorials from tutorials 2 to 4): Low participation may reflect belief that the tutorials are unnecessary, i.e., over-optimism.
- Delay between download of problem set and solution (Time in minutes between downloading the problem set and downloading the corresponding solution): A meaningful delay implies engagement and possibly more realistic self-assessment.

We will conduct heterogeneity checks by gender and ability (as already stated in the original pre-analysis-plan to also account for the Dunning-Kruger-effect.

4. Additional notes

Notes on transparency and research integrity:

- No data outside of the original dataset will be used.
- No retrospective changes are made to the original primary outcomes.

- This addendum is registered prior to conducting any of the new analyses described above.

Timeline:

- Variable coding and documentation: September 2025
- Submission of revised manuscript: October 2025

5. References

Kahneman, D., & Tversky, A. (1979). Intuitive prediction: Biases and corrective procedures. Management Science, 12, 313-327.