Pre-Analysis Plan (PAP): Learning Journal with Soft Commitment in Higher Education

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1. Motivation and Research Questions

There is an overwhelming consensus that procrastination is prevalent among people, and university students in particular. Studies estimate that over 80% of college students engage in procrastination and up to 50% do it consistently and in a way that handicaps their efforts (O'Brien, 2000; Steel 2007; Klingsieck et.al., 2013). It is thus unsurprising that a well-established body of literature links procrastination to poorer academic performance and academic failure (Kim and Seo, 2015). Given the high prevalence of procrastination and its negative consequences for academic success, this research project investigates whether a learning journal that features elements of successful mental contrasting with implementation intentions (MCII) interventions and a soft commitment device can increase students' academic performance.

Students in our **first treatment group** are offered the opportunity to use a semester long online learning journal. Given that procrastination is also described as the "quintessential self-regulatory failure" (Steel, 2007) and that studies find positive effects of interventions that aim to improve self-regulated learning (Jansen et al., 2019), the design of the learning journal draws on MCII interventions that have been successful at facilitating self-regulation, goal commitment, and goal directed behavior (Duckworth et.al 2013; Kizilcec and Cohen 2017).

Another approach that has been employed successfully to combat procrastination, lack of self-control, and self-regulatory failure is to offer individuals a commitment device (Bryan et al. 2010). In our **second treatment group**, the learning journal therefore additionally gives students the option to sign a voluntary target agreement, which lets them commit to the study time goals that they set for themselves in the learning journal. Soft commitments, i.e., commitment devices that only bear psychological costs in case of failure (Bryan et al. 2010), have the benefit of high take-up rates and can still lead to substantial increases in academic achievements (Himmler et al. 2019).

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With the intervention and the analyses presented below, we plan to answer the following main research questions:

1. To what extent do students of the two treatment groups take-up and use the learning journal?

2. Does offering a learning journal increase academic achievements in the first semester, that is, persistence, number of course credits passed, and GPA.

3. What is the effect of actual learning journal usage (take-up and frequency of usage) on academic achievements?

4. How does the additional offer of a soft commitment device affect the usage of the learning journal (take-up, frequency of usage, goal-setting behavior, and goal attainment) and its effectiveness at increasing academic achievements.

2. Sample

We conduct our intervention at a German university of applied sciences with 2,221 incoming first-semester students who enroll in one of 21 bachelor's programs in the winter semester of 2022/23. Table 1 shows the number of students per study program:

Table 1: Observations by cohorts and study programs

Study program	Freq.
Applied Chemistry	73
Applied Materials Science	55
Applied Mathematics and Physics	38
Civil Engineering	151
Business Administration	391
Electrical Engineering and Information Technology	185
Building Services Engineering	51
Energy Process Engineering	23
Computer Science	100
International Business	98
International Business and Technology	70
Management in Organic and Sustainability Business	43
Mechanical Engineering	199
Mechatronics/Precision Engineering	68
Media Engineering	71
Computer Science and Media	50
Medical Engineering	99
Social Work	296
Journalism of Technology	47
Process Engineering	25
Information Systems and Management	88
Total	2,221

For the randomization (see Section 4), the university initially provided us with administrative information on 2,224 students. However, between the randomization and the actual start of the intervention, i.e., the sending of the first letters (see Section 3), the university removed 3 duplicate observations from the data, resulting in our final sample of 2,221 students (throughout this PAP, we report descriptive statistics for the final sample). We will not exclude any students who drop out at any point after the start of the intervention from this sample.

3. Design of the Intervention

The intervention starts at the beginning of the winter semester 2022/23 (October 1). Using administrative data on students' background characteristics, on September 22, we randomized students into three different treatment groups (see Section 4 for information on the randomization procedure). At the beginning of the semester, students of all experimental groups receive an unannounced welcome letter and a corresponding email from a "competence center", i.e., an organizational unit of the university that offers and investigates, among other things, supportive measures for students. The welcome letter introduces the program "Study with a Plan", which, depending on the group, consists of the elements shown in Table 2 (Figure 1 depicts the intended timeline of the intervention). In the welcome letter (and email), students of all groups are provided the option to opt out of the program by email.
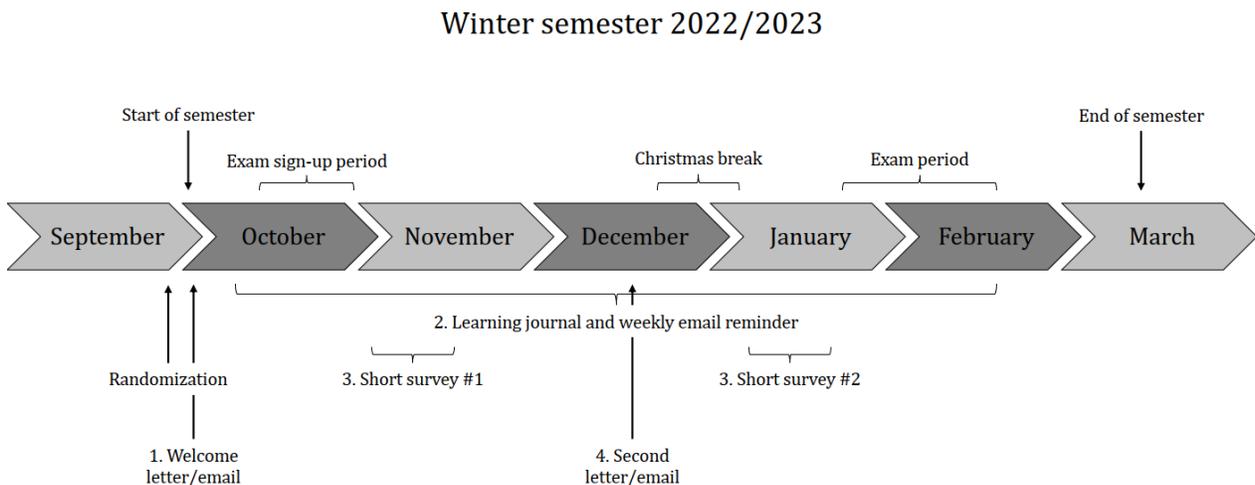

Figure 1: Intended timeline of the intervention

Table 2: Experimental design

T0: Control	**T1**: Learning Journal	**T2**: Learning Journal + Soft Commitment
1. Welcome letter/email incl. information on: i) Typical workload of a full-time study program. ii) Announcement of two short online surveys that will be conducted during the semester. iii) Second page with information on workload according to ECTS, the competence center, a diversity statement of the university, and advisory services offered by the university.	**1. Welcome letter/email incl. information on:** i) Typical workload of a full-time study program. ii) Announcement of two short online surveys that will be conducted during the semester. iii) Second page with information on workload according to ECTS, the competence center, a diversity statement of the university, and advisory services offered by the university. iv) Invitation to the online learning journal. **2. Online learning journal incl.:** i) Weekly reminder email	**1. Welcome letter/email incl. information on:** i) Typical workload of a full-time study program. ii) Announcement of two short online surveys that will be conducted during the semester. iii) Second page with information on workload according to ECTS, the competence center, a diversity statement of the university, and advisory services offered by the university. iv) Invitation to the online learning journal. **2. Online learning journal incl.:** i) Weekly reminder email ii) Voluntary target agreement
3. Two short surveys on study behavior and well-being	**3. Two short surveys on study behavior and well-being**	**3. Two short surveys on study behavior and well-being**
4. Second letter/email incl. information on: i) Upcoming exams ii) (Updated) info on points i), ii), and iii) of the welcome letter.	**4. Second letter/email incl. information on:** i) Upcoming exams ii) (Updated) info on points i), ii), and iii) of the welcome letter. iii) Learning journal reminder	**4. Second letter/email incl. information on:** i) Upcoming exams ii) (Updated) info on points i), ii), and iii) of the welcome letter. iii) Learning journal reminder

The **learning journal** is offered to students of both treatment groups (**T1** and **T2**) and consists of the following elements. Starting from the second week of the semester until the end of the exam period of the semester, the learning journal gives students the opportunity to reflect on their learning behavior of the last week and to plan ahead until the end of the next week. Specifically, students can enter the following type of information in each week:

1. Study times on each day of the last week in hours, separately for attendance and self-studying. From the second week onward students receive a notification that compares their reported study time to the goals that they initially set for the week (cf. next point).

2. Study time goals for each day of the upcoming week in hours, separately for attendance and self- studying.

3. Positive results they expect from achieving their study time goals.

4. What prevented them from achieving their goals in the last week or could prevent them from achieving their goals in the upcoming week.

5. "if-then" statements on how they will deal with the obstacles that they listed under 4 in the upcoming week.

In each week of the semester, students of the two treatment groups will receive an email reminding them to use the learning journal.

For students in treatment group **T2**, right at the beginning of the learning journal, we additionally provide the offer to sign a **target agreement**, according to which students declare "that I am committed to the study times formulated in the learning journal, and in order to study successfully with adhere to these study times", i.e., the study time goals that they set under question 2. Students are informed that signing the agreement is voluntary and that failing to meet the goals has no consequences under study or examination regulations. The text, however, states that by signing the agreement they show that they are committed to their self-set goals and that this will increase the likelihood of achieving them. Following the taxonomy of Bryan et al. (2010), the target agreement thus constitutes a **soft commitment** device. Students can sign the agreement digitally by ticking a checkbox and entering their first and last name next to it. In case students have signed the agreement, in each week, question 2 includes a notification that reminds them about their commitment.

4. Randomization Procedure

Students were assigned to one of the three experimental groups within strata that we constructed based on the following steps:

1. We split the sample based on the students' study programs resulting in 21 strata (cf. Table 1).

2. To account for differences in students' ability, within each study program, we split our sample at the median of the high school GPA distribution.[5] If this split results in two groups that include at least 24 students, we keep the two groups (14 study programs). For the other programs, we proceed without splitting the sample by high school GPA (7 study programs).[6] The second step results in 35 strata.

3. The goal of our final step is to achieve balance along a procrastination proxy that we construct based on the date of application to the university and the date of enrollment at the university, which is our main heterogeneity dimension of interest (see Section 8).[7] To

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[5] The high school GPA was missing for 42 observations. To keep the sample complete, we imputed those values based on a linear regression of the high school GPA on age, a female dummy, time since high school graduation in years, a high school degree Abitur dummy, place of high school degree dummies (foreign and other federal state, the reference group federal state is Bavaria), the procrastination index (cf. Footnote 7), a first semester at any university dummy as well as study program dummies, and the interaction of the study program dummies with the other variables.

[6] In three study programs (Applied Materials Science, Civil Engineering, Business Administration), we made a small change to the median split to achieve a more equal distribution of the two groups. E.g., in Business Administration the median split resulted in groups of 221 and 170 students, and we changed the cutoff such that the final split was 194 and 197 students.

[7] To construct the proxy, we used *Stata*'s *swindex* command by Schwab et al. (2020) to calculate the standardized inverse-covariance weighted average (Anderson, 2008) of the date of application for the study

do so, within each of the 35 strata that resulted after the first two steps, we order students according to their value of the procrastination index (ascending order) and split the sample into an even number of smaller groups of at least 12 students.[8] "Surplus" students are distributed across the two strata in the middle of the distribution starting with the stratum with the lower procrastination tendency, e.g., if there are 50 students, we create 4 strata with 12, 13, 13, and 12 students. However, if there are exactly 3 surplus students, they are allocated to one stratum together. E.g., if there are 51 students, we create 4 strata with 12, 15, 12, and 12 students. We create an even number of strata in each study program to be able to split students/strata in each study program into a group of students with low procrastination tendencies (N=1,130) and one with high procrastination tendencies (N=1,091). In total, this process results in 156 Strata. Figure 2 illustrates the formation of strata for the study program Mechanical Engineering.
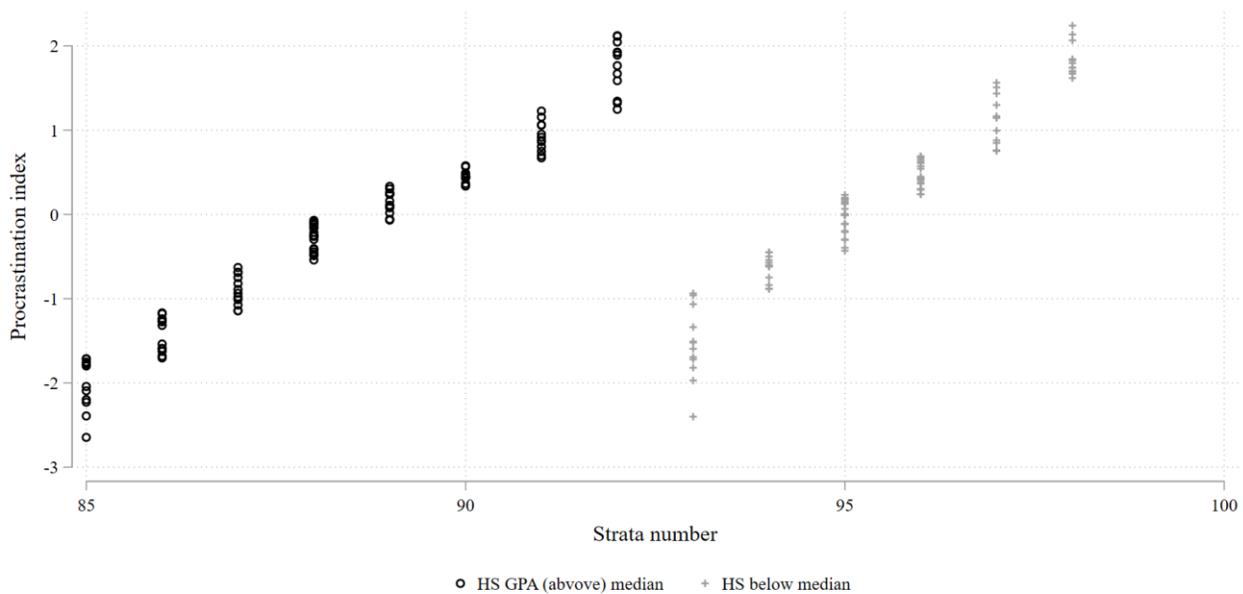

Figure 2: Randomization strata in Mechanical Engineering

The subsequent within-block randomization using equal assignment probabilities was performed with *Stata's randtreat* command (Carril, 2017).

Table 3 shows the number of observations per experimental group as well as summary statistics and balancing characteristics for the variables used to construct the blocks (high

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program and the date of enrollment. The date of enrollment was first standardized within study programs due to differences in the timelines of the enrollment periods between study programs. For the application date, we first imputed 130 missing observations based on a linear regression of the application date on the application number, study program dummies, and the interaction of the study program dummies with the application number (5 remaining missings are accounted for by the *swindex* command). Afterwards, we standardized the application date within study programs and information on whether students graduated from high school before or after the beginning of the application period, since the application behavior of those two groups differs from each other.

[8] In Energy Process Engineering, which only has 23 students, we split the sample into one group of 12 and one group of 11 students. Due to the removal of duplicates by the university (see Section 2), in the final sample, Social Work also has two strata with only 11 students.

school GPA and the procrastination index) and for additional variables (dummies for whether the high school GPA and the application date to university were missing, female dummy, age at beginning of the semester, time since high school graduation in years at the beginning of semester, a dummy for whether it is the first semester at any university, a high school degree "Abitur" dummy[9], and dummies for place of high school degree (other federal state and foreign; reference category is Bavaria)). The F-tests used for the construction of the p-values are based on regressions of the respective covariates on the treatment group dummies that control for strata fixed effects (FE) and use robust standard errors.

Table 3: Summary statistics and balancing properties

	All	**T0**	**T1**	**T2**	**p-value F-test**
Stratification variables					
Procrastination index	-0.000	-0.001	-0.012	0.011	0.747
(Std. dev.)	(1.000)	(1.022)	(1.015)	(0.965)	
HS GPA	2.477	2.472	2.469	2.489	0.478
(Std. dev.)	(0.606)	(0.613)	(0.608)	(0.596)	
Additional covariates					
App. data N/A	0.061	0.064	0.064	0.055	0.646
HS GPA N/A	0.019	0.018	0.018	0.022	0.806
Female	0.370	0.378	0.384	0.348	0.196
Age	21.355	21.425	21.228	21.411	0.358
(Std. dev.)	(3.197)	(3.081)	(3.066)	(3.429)	
Time s. grad. (in years)	1.623	1.684	1.561	1.624	0.605
(Std. dev.)	(2.509)	(2.511)	(2.386)	(2.627)	
First university semester	0.757	0.766	0.759	0.745	0.573
HS degree Abitur	0.524	0.528	0.530	0.514	0.779
HS deg. other fed. state	0.096	0.108	0.097	0.084	0.251
HS deg. foreign	0.040	0.035	0.046	0.038	0.568
N	2,221	740	740	741	

5. Statistical Power

Assuming alpha = 0.05, we calculate effect sizes for comparisons between the experimental groups using the Stata power *twomeans* command for an R^2 of 0.00 (Column 3) and, using the Optimal Design software (Spybrooks et al., 2011), for assumed R^2s of 0.20 and 0.40 (Columns 4 and 5; we assume equal group sizes, because Optimal Design does not allow for uneven splits). The two latter R^2s are based on analyses with previous cohorts that show that the variables used for blocking (study program dummies, the procrastination index, and high school GPA) explain up to 40% of the variance in our primary outcomes. Our detectable effect sizes range between 0.073 to 0.208 standard deviations, depending on the sample and the analysis. In the context of education, these correspond to medium effect sizes (Kraft 2020).

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[9] High school degree Abitur refers to the German general track degree. It is one of the two main secondary school degrees in the tracked school system in Germany that qualifies students to study at a University of Applied Sciences; the second being the vocational track degree (Fachhochschulreife).

Table 4: Minimum detectable effect sizes

Power	N	Delta ($R^2 = 0.00$)	Delta ($R^2 = 0.20$)	Delta ($R^2 = 0.40$)
a) T0 vs. T1&T2				
0.6	2,221	0.100	0.085	0.073
0.8	2,221	0.126	0.106	0.092
b) T0 vs. T1&T2 among procrastinators				
0.6	1,091	0.142	0.120	0.105
0.8	1,091	0. 180	0.152	0.131
c) T0 vs. T1, T0 vs. T2, or T1 vs. T2				
0.6	1,480	0.115	0.103	0.089
0.8	1,480	0.146	0.130	0.113
d) T0 vs. T1, T0 vs. T2, or T1 vs. T2 among procrastinators				
0.6	726	0.165	0.147	0.128
0.8	726	0.208	0.186	0.161

6. Data Sources

For the analyses of the effects of the intervention, we plan to use data from the following sources:

Administrative data: The university provides us with administrative data on students' background characteristics and information from the application process. Some of the information from those sources was used in the randomization procedure and we plan to use some of it as covariates and for potential heterogeneity analyses.

The university will further provide us with information on the number of exams/credits that students sign up for[10] and with information on students' academic achievements, e.g., the number of attempted and passed course credits, GPA, and persistence (=1-dropout). We will use information from these sources for our outcome variables.

Online-Self-Assessments (OSAs): During the enrollment process, students of nine study programs are obliged to complete a subject-specific online self-assessment. Students from the other programs can also take those subject-specific self-assessments or a voluntary general self-assessment. We were allowed to include a short module in the OSAs that takes about five minutes to complete. The module includes questions on subjects such as time preferences, procrastination tendencies, expected weekly study time during the semester, and socio-economic background. We plan to match the data from the OSAs with the administrative data.

Online surveys: As explained in Section 3, we will invite students to participate in two short voluntary online surveys in which we will ask them about their study behavior as well as

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[10] To take exams students must sign up for them in advance during the sign-up period (see Figure 1). However, depending on the study program, students can later deregister from taking the exams that they signed up for; either during a specific deregistration period or by simply not showing up to the exam.

questions on non-cognitive outcomes such as stress, study satisfaction, and satisfaction with life in general.

Learning journal: For the two treatment groups, we will have access to students' responses in the learning journal. Among other things, this includes information on the usage of the learning journal (take-up and frequency), the weekly hours that students reportedly invest in studying, the study time goals that they set, and whether students in **T2** take up the soft commitment.

7. Variables

Primary outcome(s): The primary outcomes of the intervention are usage of the learning journal (take-up and frequency), persistence, the number of passed course credits, and students' GPA[11] at the end of the first semester. Since we have no clear hypothesis which of the three measures of academic achievement should be most affected by our intervention, we will additionally create an index based on the standardized inverse-covariance weighted average of those outcomes (Anderson, 2008; Schwab et al., 2020).

Secondary outcomes: To investigate whether our intervention affects students' engagement with their studies, we will study the effect of the intervention on course credits signed up for and attempted as well as students study behavior. Study behavior is measured in the two online surveys.

To investigate how students' well-being is affected by the intervention, we study effects on the non-cognitive outcomes that we measure in the online surveys. For the effects on non-cognitive outcomes, we will also construct a well-being index based on the standardized inverse-covariance weighted average of those outcomes (Anderson, 2008; Schwab et al., 2020).

To study how the offer and take-up of the soft commitment affects the usage of the learning journal, we will study effects on students' goal setting behavior, their actual study time, and their goal achievement.

Covariates: In some of our regression specifications, we will not only include strata FE but also additional covariates to improve the precision of the estimates (see Section 8). Currently, this includes all covariates shown in Table 3. For the selection and inclusion of any additional covariates in the specifications of our main analyses beyond those just mentioned, e.g., to further increase the precision of the estimates, we will rely on the double post-lasso approach proposed by Belloni et al. (2014).

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[11] Since the GPA is only observed for students who pass at least one graded module and because all outcomes from the online survey are only observed for students who answer the respective question, we will study whether observing these outcomes is affected by treatment and, if applicable, control for potential differences using inverse probability weighting.

8. Analyses

8.1 Main Analysis

In our main analysis, we will focus on the effects of our intervention on learning journal usage (take-up and frequency of usage) and academic achievements in the first semester (academic achievement index, persistence, course credits passed, and GPA).

8.1.1 Intention-to-Treat Effects

In the first step, we will estimate effects of offering students the opportunity to use the learning journal on learning journal uptake and usage as well as academic achievements, i.e., we estimate intention-to-treat (ITT) effects. We will perform those analyses using OLS regressions with the following two baseline specifications:

1. $\quad y_i^k = \alpha_0 + \alpha_1 T_i + x_i \beta + s_i + \varepsilon_i,$

where y_i^k is one of the primary outcomes of interest, T_i is a dummy for being randomized into either of the two treatment groups that are offered a learning journal, s_i are FE that control for the random assignment within blocks, and x_i is a vector that includes the covariates specified in Section 7, which we add in an additional specification to increase the precision of our estimates. Based on this specification, we will test: $H_0: \alpha_1 = 0; H_1: \alpha_1 \neq 0.$

2. $\quad y_i^k = \alpha_0 + \alpha_1 T1_i + \alpha_2 T2_i + x_i \beta + s_i + \varepsilon_i,$

where we now distinguish between, $T1_i$ and $T2_i$, i.e., whether students are randomized into the learning journal with or without the soft commitment. All other parameters are defined as before and we will test the following hypotheses:

 i. $H_0: \alpha_1 = 0; H_1: \alpha_1 \neq 0.$

 ii. $H_0: \alpha_2 = 0; H_1: \alpha_2 \neq 0.$

 iii. $H_0: \alpha_2 - \alpha_1 = 0; H_1: \alpha_2 - \alpha_1 \neq 0.$

8.1.2 Treatment Effect on the Treated

Conditional on the results in 8.1.1., we are additionally interested in how learning journal usage affects students' academic achievements. Therefore, we will also estimate treatment effects on the treated adopting the methodology from Angrist et al. (1996), i.e., we will perform two-stage least square estimations using treatment assignment as an instrument for learning journal usage. We do so based on the following specifications:

3.1 $\quad usage_i^k = \alpha_0 + \alpha_1 T_i + x_i \alpha_2 + s_i + \varepsilon_i$

3.2 $\quad achievement_i^k = \gamma_0 + \gamma_1 usage_i^k + x_i \gamma_2 + s_i + \varepsilon_i,$

where $usage_i^k$ (i.e., take-up or frequency of usage) is instrumented by treatment assignment to estimate the effect of $usage_i^k$ on the different first semester achievement measures.

As before, we will also distinguish between the two types of learning journals and estimate separate effects of treatment on the treated using the following specifications:

4.1 $\quad T1\_usage_i^k = \alpha_0 + \alpha_1 T1_i + \alpha_2 T2_i + \boldsymbol{x_i \alpha_3} + \boldsymbol{s_i} + \varepsilon_i$

4.2 $\quad T2\_usage_i^k = \beta_0 + \beta_1 T1_i + \beta_2 T2_i + \boldsymbol{x_i \beta_3} + \boldsymbol{s_i} + \varepsilon_i$

4.3 $\quad achievement_i^k = \gamma_0 + \gamma_1 T1\_usage_i^k + \gamma_2 T2\_usage_i^k + \boldsymbol{x_i \gamma_3} + \boldsymbol{s_i} + \varepsilon_i,$

Where we use assignment to **T1** and **T2** as instruments for **T1** and **T2** usage, respectively.

8.2 Secondary Analyses

1. To study if and how the learning journal affects the way in which students engage with their studies, we will investigate whether the learning journal increases the number of course credits signed up for and attempted as well as the time spent on studying as measured in the two online surveys. In addition, we will use data from the learning journal to study whether offering students a soft commitment affects goal setting, study time, and goal achievement compared to the learning journal without the soft commitment.

2. We will assess the "net effects" of the intervention by analyzing how the intervention affects students' non-cognitive outcomes that we elicit in the two online surveys.

3. We will explore whether treatment effects are heterogeneous with respect to students' procrastination tendencies, which we measure in two ways. First and foremost, we rely on the procrastination index that we constructed based on students' application and enrollment date, which we used for the randomization process (see Section 4). We are interested both in interactions with the continuous procrastination index as well a dummy that indicates whether a student is part of a strata with above median procrastination tendencies. Second, we will also use survey-based procrastination measures from the OSAs (cf. Section 6).

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