

## PAPER 4

### Self-testing in higher education: What predicts the use of self-testing and who achieves their goals?

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#### Abstract (100 – 250 words)

Practice tests in conjunction with performance feedback can support student self-regulation (Ibabe & Jauregizar, 2010). However, evidence suggests that students' willingness to take self-tests is often low (e.g., about 25% in Förster et al., 2018). To date, we know very little about the psychological characteristics of students who are most likely to use and benefit from self-testing. Accordingly, using a wide range of predictor variables and the machine learning approach LASSO, this study examined the psychological characteristics of students who are most likely to use self-tests, meet their self-set course goals, and use self-tests continuously throughout the semester. We used data from two studies: economics students ( $N=312$ , 54% female) enrolled in a first-semester mathematics gateway course (Study 1) and social science students ( $N=117$ , 58% female) enrolled in a third-semester statistics course (Study 2). In both studies, students had different opportunities to self-test during the semester. There was little overlap in the selected variables for the number of self-test attempts or achievement of self-set self-testing goals between the two studies. Finally, the results highlight the need to consider not only the psychological but also contextual features of self-testing.

#### Extended summary (600 - 1000 words, including references)

##### Objectives

Practice testing is one of the best-researched learning techniques in the educational sciences (Yang et al., 2021). Along with performance feedback, it supports students' self-regulation because students gain knowledge about their ability levels (i.e., metacognitive knowledge) and can monitor their learning progress (Ibabe & Jauregizar, 2010). However, evidence suggests that students' willingness to self-test is often low (e.g., about 25% in Förster et al., 2018; see also Authors 1 and Authors 2). Even when students are informed of the benefits of self-testing, many fail to adapt their study behaviors, likely because self-testing is effortful (Dunlosky & Rawson, 2015; Sussan & Son, 2014). Finally, students with comparatively more advantageous academic characteristics are more willing to use and benefit from self-testing (Förster et al., 2018), even though making self-testing mandatory benefits low-achievers most (Chevalier et al., 2018).

However, to date, we know little about the psychological characteristics of students who use and benefit from self-testing (e.g., their academic motivations, personality characteristics, time preferences, and goals; Förster et al., 2018). Gaining a better understanding of these psychological factors is vital for designing personalized and motivating self-regulation interventions. Thus, using a broad range of predictor variables and the machine learning approach LASSO, this study examined the psychological characteristics of students who are most likely to (RQ1) use self-testing, and (RQ2) achieve their self-set self-testing goals.

## Methodology

We used data from two studies: Economics/business administration students ( $N=312$ , 54% female) enrolled in a first-semester math course (Study 1) and social science students ( $N=117$ , 58% female) enrolled in a third-semester statistics course (Study 2); both from the same large public German university. In Study 1, students could participate in three 30-minute online practice tests. The first try was incentivized with extra credit, and students were allowed to redo the practice test without any reward. In Study 2, the students had access to thirteen weekly non-incentivized online exercises. In both studies, participation was voluntary, and students received automated corrective feedback. Additionally, student information, prior performance, motivational beliefs, personality traits, time preferences, and self-set course goals were assessed at the beginning of the semester (see Tables 1 and 2). In two other studies, we have shown that the use of these self-tests is positively related to exam performance (Authors 1; Authors 2)

For RQ1, we counted the number of self-tests: In Study 1, we combine the number of incentivized and non-incentivized practice tests, while in Study 2, it is the number of (non-incentivized) online exercises. For RQ2, we relate the number of self-tests to students' goals to self-test at the beginning of the semester (1=unachieved; 2=achieved; 3=exceeded). For Study 1, we differentiated between the number of incentivized (Achieving Goal 1) and non-incentive practice tests (Achieving Goal 3), while we only can look at non-incentivized self-testing (Achieving Goal 1) in Study 2.

## Results

The post-selection regressions (Table 3) included only previously selected variables in the LASSO. In Study 1 (RQ1), the following variables were selected as predictors of self-testing frequency: students' high-school GPA, available financial resources, whether the course is part of their major, their father's occupation, and students' self-set self-testing goals for the number of self-tests to complete. Students' motivation, achievement goals, personality, and time-preferences were not selected. In Study 2 (RQ1), we find that women and students who passed the prior statistics course completed more online self-tests. In contrast to Study 1, students' statistics self-concept, attainment value, and mastery approach were also selected by the LASSO analysis as motivational predictors of the number of attempts.

Concerning RQ2, the post-selection regression identified different sets of predictors for attaining self-set practice goals for incentivized vs. non-incentivized online practice tests in Study 1. Whereas a broad range of motivational and personality variables significantly predicted students' attainment of self-set practice goals in incentivized self-tests (e.g., math self-concept, extraversion, openness, and risk aversion), only students' present time bias and the self-set practice goal were predictive of non-incentivized self-testing. For Study 2, students' attainment of self-set practice goals was predicted by their need to work, their self-testing goal, and students' math self-concept, attainment value, and costs.

## Discussion

First, the overlap of which variables were selected as predictors of the number of self-testing attempts or the attainment of self-set self-testing goals between Studies 1 and 2 was rather low. Moreover, although math self-concept was selected by the LASSO algorithm in both studies, the direction of the coefficient differed. In addition, whereas comparatively more ambitious self-testing goals *positively* predicted the number of practice attempts for the incentivized practice tests (Study 1), they *negatively* predicted whether students achieved their goals (Studies 1 and 2). This is not surprising, because the higher the goals are, the more difficult it becomes to achieve them.

Second, while student demographic background and personality play a greater role in Study 1, motivation is more critical in Study 2. This difference may be due to the different study programs or designs. This seems reasonable, as incentivizing participation tends to result in less self-selection (Chevalier et al., 2018).

Finally, the results highlight the need to attend not only to psychological but also contextual self-testing features (e.g., the psychological implications of incentivized participation).

## References

Authors 1

Authors 2

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**Table 1.**  
Descriptive statistics of variables used in both studies

	Study 1			Study 2		
	N	Mean	SD	N	Mean	SD
<b>Student information</b>						
Raven Score	416	4.15	2.82	85	0.57	0.16
Age	334	20.92	2.22	81	23.07	3.29
Female	389	1.54	0.50	83	0.58	0.50
HS GPA	315	2.19	0.62	83	2.66	0.61
Math LK	304	0.81	0.40	78	0.71	0.46
Last math grade	315	2.76	1.16	83	3.36	1.13
Monthly financial resources	243	632.69	391.97	75	642.45	253.90
Rent	247	299.51	211.36	69	290.28	170.15
Working	288	0.48	0.50	78	0.79	0.41
Work to finance studying	295	0.25	0.43	74	0.42	0.50
<b>Parental background</b>						
Mother HS grad.	298	0.50	0.50	70	0.43	0.50
Father HS grad.	301	0.64	0.48	73	0.44	0.50
Tertiary education mother	297	2.34	0.59	73	2.08	0.52
Tertiary education father	296	2.49	0.59	72	2.24	0.64
Occupation type mother	300	2.89	0.99	76	2.20	0.86
Occupation type father	294	2.64	0.60	71	2.69	0.65
Highest education parents	301	0.64	0.48	75	0.57	0.50
Highest tert. edu. parents	300	2.58	0.55	74	2.42	0.55
Highest occ. par.	304	3.06	0.81	77	2.84	0.56
<b>Expectancy-value belief</b>						
EVT: Self-Concept	318	2.65	0.64	82	2.46	0.68
EVT: Intrinsic value	316	2.69	0.61	82	2.48	0.63
EVT: Attainment value	315	2.05	0.56	82	2.28	0.65
EVT: Utility value	314	3.47	0.55	78	3.11	0.64
EVT: Cost	315	2.39	0.55	82	2.12	0.55
<b>Achievement goals</b>						
AG: Mastery approach	308	6.08	0.79	82	5.61	0.92
AG: Mastery avoidance	308	5.60	1.01	81	5.01	1.33
AG: Performance approach	303	4.81	1.56	77	3.90	1.66
AG: Performance avoidance	301	4.81	1.67	75	3.70	1.74
<b>Big Five</b>						
BF: Conscientiousness	313	4.90	1.08	81	4.52	1.07
BF: Extraversion	313	4.93	1.30	81	5.01	1.15
BF: Agreeableness	313	5.51	1.05	81	5.65	0.92
BF: Openness	311	4.91	1.17	81	5.25	0.96
BF: Neuroticism	313	4.38	1.26	81	4.26	1.17
<b>Time preferences</b>						
PBP: Risk	307	0.68	0.20	82	0.70	0.18
PBP: Discount factor	301	1.00	0.67	80	0.94	0.22
PBP: Present bias	300	1.06	0.31	80	1.11	0.55
<b>Self-set course goals</b>						
Goal 1: How many online self-tests?	310	2.78	0.51	83	7.66	3.68
Goal 2: Aspired performance in online self-tests?	310	0.78	0.14	83	0.73	0.18
Goal 4: Aspired grade in the exam?	310	2.10	0.64	83	2.26	0.61

**Table 2.**

Descriptive statistics of variables which differ between both studies

	Study 1			Study 2		
	N	Mean	SD	N	Mean	SD
<b>Online practice tests with reward – study 1</b>						
Took first practice test with reward	416	0.86	0.35	-	-	-
Took second practice test with reward	416	0.79	0.41	-	-	-
Took third practice test with reward	416	0.71	0.45	-	-	-
<b>Online practice tests without reward – study 1</b>						
Took first practice test without reward	416	0.14	0.35	-	-	-
Took second practice test without reward	416	0.14	0.34	-	-	-
Took third practice test without reward	416	0.08	0.27	-	-	-
<b>Number of practice tests with and without rewards, and combined – study 1</b>						
Number of practice tests with reward	416	2.36	0.99	-	-	-
Number of practice tests without reward	416	0.36	0.68	-	-	-
Number of practice tests (total)	416	2.72	1.26	-	-	-
<b>Achieving self-set practice test goal – study 1</b>						
Relation practice tests with reward and self-set goals	310	1.90	0.57	-	-	-
Relation practice tests without reward and self-set goals	310	1.30	0.59	-	-	-
<b>Study specific student variables – study 1</b>						
International BA or Econ	416	0.39	0.49	-	-	-
Major in Sport	416	0.06	0.24	-	-	-
BA or Econ as a minor	416	0.25	0.43	-	-	-
Goal 3: Practicing after external reward?	310	1.26	0.46	-	-	-
<b>Online exercise variables – study 2</b>						
Number attempts self-tests	-	-	-	118	3.07	4.42
Spacing	-	-	-	118	0.58	1.10
<b>Study specific student variables – study 2</b>						
Number of semesters	-	-	-	83	4.34	2.21
Retaking statistics 2	-	-	-	83	0.14	0.35
Stand. points. statistics 1	-	-	-	117	-0.25	1.02
Passed statistics 1	-	-	-	117	0.77	0.42
<b>Achieving self-set online exercise goal – study 2</b>						
Interested in Quant (vs. Qual)	-	-	-	54	0.69	0.47
Goal 3: Solving the e-learning exercises weekly?	-	-	-	83	1.47	0.63
Achieving self-set goal 1	-	-	-	83	1.47	0.83

**Table 3.**  
Regression results.

	Study 1 - online practice tests			Study 2 - online exercises	
	Number of Self-tests	Achieving Goal 1	Achieving Goal 3	Number of Self-tests	Achieving Goal 1
Female				1.810*	
				(0.784)	
HS GPA	-0.308**	-0.208***			
	(0.107)	(0.050)			
Financial resources	-0.061***	-0.022**			
	(0.015)	(0.008)			
Working		-0.080			-0.132
		(0.058)			(0.151)
BA or Econ as a minor	-0.440*	-0.215*			
	(0.184)	(0.093)			
Occupation type father	0.458***	0.170***			
	(0.116)	(0.051)			
EVT: Self-Concept		-0.060		1.942**	0.385**
		(0.045)		(0.709)	(0.131)
EVT: Intrinsic value					
EVT: Attainment value				-0.325	-0.052
				(0.557)	(0.115)
EVT: Cost					-0.245*
					(0.103)
AG: Mastery approach				0.590	
				(0.420)	
BF: Extraversion		0.042 <sup>+</sup>			
		(0.022)			
BF: Openness		-0.059*			
		(0.025)			
PBP: Risk		0.296 <sup>+</sup>			
		(0.156)			
PBP: Present bias			0.236 <sup>+</sup>		
			(0.123)		
Goal 1: How many online self-tests?	0.322*	-0.488***			-0.063***
	(0.129)	(0.079)			(0.017)
Goal 3: Practicing after external reward?			-0.293***		
			(0.048)		
Passed statistics 1				2.264**	
				(0.691)	
R2	0.189	0.362	0.076	0.303	0.319
Adj.R2	0.175	0.341	0.070	0.272	0.288
N	312	312	312	117	117
Number of parameters	5	10	2	5	5

Note: \*\*\*  $p < 0.001$ ; \*\*  $p < 0.01$ ; \*  $p < 0.05$ ; <sup>+</sup>  $p < 0.1$