

Does Using Structured Learning Diaries Affect Self-regulation or Study Engagement?

An Experimental Study in Engineering Education

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Abstract—(Research - Full Paper) Previous research suggests that structured learning diaries can increase students’ self-regulation skills. However, learning diaries also imply great effort for students, and more research is needed to understand the effect of diaries on students’ motivation and engagement. In the current study, we investigate whether our approach of using curricular concept maps as structured learning diaries has an effect on students’ self-regulation or study engagement. 104 first-year engineering master’s students were randomly assigned to experimental and control groups. The structured learning diary using a digital tool was a compulsory weekly assignment for the experimental group. Both groups completed pre- and post-test questionnaires on self-regulation and study engagement. Using Repeated Measures ANOVA, we did not find statistically significant differences between the experimental and the control groups in self-regulation or study engagement. However, with a more fine-grained grouping based on diary usage, we found a statistically significant decrease in passive diary users’ dedication (part of study engagement). Our results indicate that making students actively use reflection tools such as structured learning diaries remains a challenge. Moreover, such an intensive intervention may even have negative effects on study engagement for students who do not actively use the tool.

Index Terms—self-regulation, study engagement, learning diary, intervention tool, experimental design

I. INTRODUCTION

In modern self-paced learning, students’ self-regulatory skills are becoming increasingly important. Self-regulated learning (SRL) is a core conceptual framework for understanding the cognitive, motivational and emotional aspects of learning [1]. Self-regulating learners actively reflect on what they learn and how well their goals are achieved by variations in their approaches to learning [2]. In the university context, good self-regulation skills are related to higher academic achievement and lower levels of stress and study-related exhaustion [3]–[5].

Another aspect that is very central to a student’s achievement and well-being is study engagement [6]. In the present study, we define study engagement as a positive, fulfilling state of mind, characterized by energy, dedication and absorption while studying [7], [8]. Higher education students’ engagement in their studies is associated with higher learning

and achievement measures [9], [10]. Study engagement can also be seen as the opposite of study burnout [7]. Salmela-Aro and Read [11] found that students tended to report more engagement in the earlier stages of their studies while having fewer study demands and sufficient resources, while burned-out and inefficacious students had been studying the longest and reported having increasing study demands and simultaneously fewer resources to cope with them.

Engagement in learning activities occurs in close connection and reciprocally with self-regulation [12]. There is an overlap between these two frameworks: definitions of student engagement include self-regulation strategies and definitions of self-regulated learning identify active engagement as a key component [13]. However, there might be decisive differences regarding students’ learning goals and the source of motivation. While two students may show similar engagement, their engagement may be self-regulated or regulated externally by the teacher. On the other hand, two students may both have excellent self-regulation skills, but still display very different levels of engagement, due to lack of interest, for example. Boekaerts [12] aptly describes engagement and self-regulation processes as “parallel paths with interconnecting side paths”.

A. Self-regulated learning (SRL) measurement and intervention tools

Meta-analytical evidence suggests that properly designed self-regulation interventions demonstrate a generally positive impact on academic achievement and motivation [1], [14], [15]. Interventions aimed at improving students’ SRL skills include both guidance and instruction on SRL strategies and the use of metacognitive tools such as structured learning diaries.

Panadero, Klug and Järvelä [16] propose that learning diaries represent the “third wave of SRL measurement” (first wave: self-reports, second wave: online measures) where intervention and assessment go hand in hand: students’ reflections on their actions also have an effect on their prospective learning actions. This effect, called reactivity, is a crucial aspect of the self-regulation process.

An important question is, whether tools such as learning diaries alone can have an effect on students SRL. Several studies show that learning diaries combined with SRL training generally have a positive effect [17], [18]. On the other hand, Fabriz, Dignath-van Ewijk, Poarch and Büttner [18] found that keeping a structured learning diary without any further intervention did not improve self-regulation. Joseph-Edwards [19] found, that students who received a learning diary intervention were significantly more accurate in their metacognitive judgements compared to the control group. No significant effect of the treatment was observed on self-regulated learning behaviors or academic achievement, however. Dörrenbächer and Perels [20] specifically addressed this question with a 2x2x2 control-group design. They found that content-independent SRL training positively influenced SRL, whereas the learning diary alone had no effects. The combination of both interventions produced the highest effect.

While there is evidence that SRL interventions have an effect on learning [15], it should also be taken into account that effects may differ with different kinds of student profiles. Dörrenbächer and Perels [21] investigated college students SRL profiles using latent profile analysis. They found that most skilled profiles are consistent with higher academic achievement. Moreover, they found that only students with moderate and motivated SRL-profiles benefit from SRL training. It is acknowledged that learning diaries imply a great effort for the students [16], [17], [22] and that their motivation may decrease over time if they do not perceive a learning gain in light of the extra activity that instrument entails [16]. More research is needed to understand how interventions may also affect students' motivation and engagement.

One factor that could have an effect on how students see the relevance of the instrument concerns how it is aligned with their curriculum contents. Previous examples of structured learning diaries typically use question items concerning studying in general, such as "How do you feel at the moment?", "Today, I am satisfied with my learning results." [17]; "Today I have evaluated my goal achievement." [20]. Their alignment with curriculum contents is not explicit but depends on which topics students' are studying each day. Undergraduate students typically have multiple courses ongoing with a wide variety of topics. With the aim of aligning diary activity with curriculum contents, we designed a methodology whereby curricular concept maps form a foundation for the structured learning diary [23]. Based on a predefined concept map structure derived from the curriculum, students were asked to answer standardized items (e.g. competence and difficulty evaluations) and open items (e.g. goal-setting, reflection) regarding different parts of the curriculum (see [23] for a more detailed description).

B. Aims of the study

Based on previous research, it is clear that improving students self-regulated learning skills is important, and that structured learning diaries are a potential tool supporting this aim. However, since the results of intervention studies are

somewhat inconsistent, further research is needed in regard to how students use learning diaries and whether some students benefit from diaries more than others.

Moreover, structured learning diaries require significant effort from the subject [22]. How students react to the effort required, largely depends on whether they see the value of the exercise. Hence, it is important to investigate the effect of learning diaries on students' general motivational disposition in regard to their studies (i.e. study engagement). In the current study, we investigate whether an approach of using curricular concept maps as structured learning diaries has an effect on students' self-regulation skills and study engagement.

II. METHODS AND MATERIALS

A. Context

The study was conducted during a *Mechanical Engineering in Society* course offered by a large Finnish research university. The mandatory first-year course was part of a two year (120 ECTS¹) Mechanical Engineering Master's program, which started in fall 2018. The program included project courses (e.g. Machine Design Project), that focus on integrating engineering skills from common studies and their application in practice. The course in question here, *Mechanical Engineering in Society*, was tightly integrated with these project courses and focused on transferable skills and the development of students' professional identity.

During the course, students were instructed to participate the public events (e.g., project demonstrations) of these project courses and in that way get inspiration from the community. Hence, reflecting on the contents of the whole program was essential on this particular course, making it a compelling arena for the structured learning diary exercise. While typically learning diaries are used for reflecting on contents of a single course, here students used the diary to reflect on the contents of the whole program.

The course lasted two semesters (Fall 2018 and Spring 2019; 5 ECTS in total) – The present study will focus on the first half of the course. Grading for the course was based on 1) attendance of the orientation week activities (10% of the total grade), 2) writing a short essay on three freely selected industry lectures, research lectures or seminars (30%), and 3) a learning portfolio (60%).

B. Participants

All of the students embarking on the Master's Program in Mechanical Engineering in fall 2018 ($N = 114$) were invited to the study and 104 agreed to participate. Participants were randomly assigned to an experiment group ($N = 70$) and a control group ($N = 34$). Most of the participants (91.3%) were male, reflecting the typical gender distribution in engineering education at the university in question. Age of participants ranged from 22 to 58, with the mean age being 25.3 and the median 23.

¹European Credit Transfer and Accumulation System (ECTS)

C. Intervention: Structured Learning Diary

The structured learning diary was a mandatory, albeit ungraded weekly assignment during the course. The intervention group (Group A) conducted the learning diary assignment during autumn 2018, and the control group (Group B) during spring 2019. The diaries were completed by using a digital tool called Dynamic Feedback System (DFS) [23].

In DFS, students interact with a concept map consisting of a four-level (degree, module, course and topic) tree structure of curriculum content (Fig 1). The curriculum structure is included in the template given to students. The concept map comprises multiple features for interaction. The features students were instructed to use are presented below.

a) *Topic relationships*: Students were asked to draw meaningful connections between different topics belonging to their Master's Program curriculum.

b) *Reflective comments*: Students were asked to reflect on their learning in relation to different courses and topics. To facilitate reflection, example questions were presented (e.g. "What is essential concerning this topic?", "What is the significance of this topic for me personally?").

c) *Topic emotions*: Students were asked to indicate their emotions using emoticons next to each topic on the concept map. The classification of emotions was based on a two-dimensional taxonomy of achievement emotions [24], with emoticons representing neutral, excited (positive-activating), relaxed (positive-deactivating), anxious (negative-activating) and bored (negative-deactivating).

d) *Topic competence evaluation*: Students were asked to evaluate their competence on each topic studied during the ongoing week (on a scale of 1 (Low) to 5 (High), blue boxes in Figure 1).

e) *Topic difficulty evaluation*: Students were asked to evaluate the difficulty of each topic studied during the ongoing week (on a scale of 1 (Easy) to 5 (Difficult), black boxes in Figure 1).

Students were requested to update their evaluations each week. For example, during the first week a student might evaluate her competence in a topic as low. Later, when learning more about the topic, she could re-evaluate her competence at a higher level. Only the most recent evaluations were visible in the learning diary tool. However, earlier evaluations could be accessed through previous file versions.

D. Measures

All of the participants completed pre- and post-test questionnaires on self-regulation and study engagement. The questionnaires were distributed using the university's official learning management system (Moodle LMS). The pre-test questionnaire was conducted during the first week of the fall semester (including background information) and the post-test questionnaire during the last week of the semester. All of the 104 participants completed the first questionnaire and 88 (84.6 %) the second.

a) *Self-regulation*: In order to measure the students' self-regulation skills, a scale deriving from the Inventory of Learning Styles (ILS) [25] and modified by Räsänen and colleagues [5] was used. The modified scale consists of 11 items that load onto three factors: self-regulation of content (3 items; e.g. "If I do not understand the subject matter, I search for more material related to the subject concerned."), self-regulation of process (4 items; e.g. "When I have difficulty understanding particular subject matter, I try to analyze why it is difficult for me.") and lack of regulation (4 items; e.g. "It is difficult for me to determine whether I have mastered the subject matter sufficiently."). The items were rated on a scale ranging from 1 ('Completely disagree') to 7 ('Completely agree').

b) *Study engagement*: For the purpose of measuring study engagement, we used the schoolwork engagement inventory [8]. The inventory consists of nine items that load onto three factors: energy (3 items; e.g., "When I study, I feel I'm bursting with energy"), dedication (3 items; e.g., "I find my studies full of meaning and purpose") and absorption (3 items; e.g., "Time flies when I'm studying"). The items were rated on a scale ranging from 1 ('Totally disagree') to 6 ('Totally agree').

c) *Diary usage*: Diary usage statistics were calculated according to the students weekly learning diary files. For each feature of the diary tool (topic relationships, reflective comments, topic emotions, competence evaluation, difficulty evaluation), raw scores describing the number of changes made to the files were calculated. The usage of each feature was then scaled to an interval [0,1], and the total diary usage was measured as an average of the scaled components.

d) *Academic achievement*: Academic achievement data were collected from the student registry in early 2019, after the registrations for fall semester 2018 were complete. The sum of the credits (ECTS) and credit-weighted grade point average (GPA; ranging from 1 (sufficient performance) to 5 (excellent performance)) were calculated. Since the course *Mechanical Engineering in Society* during which the intervention was carried out was graded at the end of spring semester 2019, it is not included in the achievement data.

E. Analyses

Pairwise Pearson correlations between initial self-regulation (i.e., self-regulation of content, self-regulation of process, lack of regulation), initial study engagement (i.e., energy, dedication, absorption), learning diary total usage and academic achievement (i.e., GPA and sum of credits) were run to determine the relationships between the different measures.

As the total diary usage was unevenly distributed, the experimental group was further divided into two subgroups: active users (N=26) who had total usage above 0.2 and passive users (N=35) with their total usage below 0.2. The cutting point was selected based on the distribution of the usage illustrated in Figure 2.

Independent samples T-tests, Chi-square tests and One-way analysis of variance (ANOVA) were used to determine whether

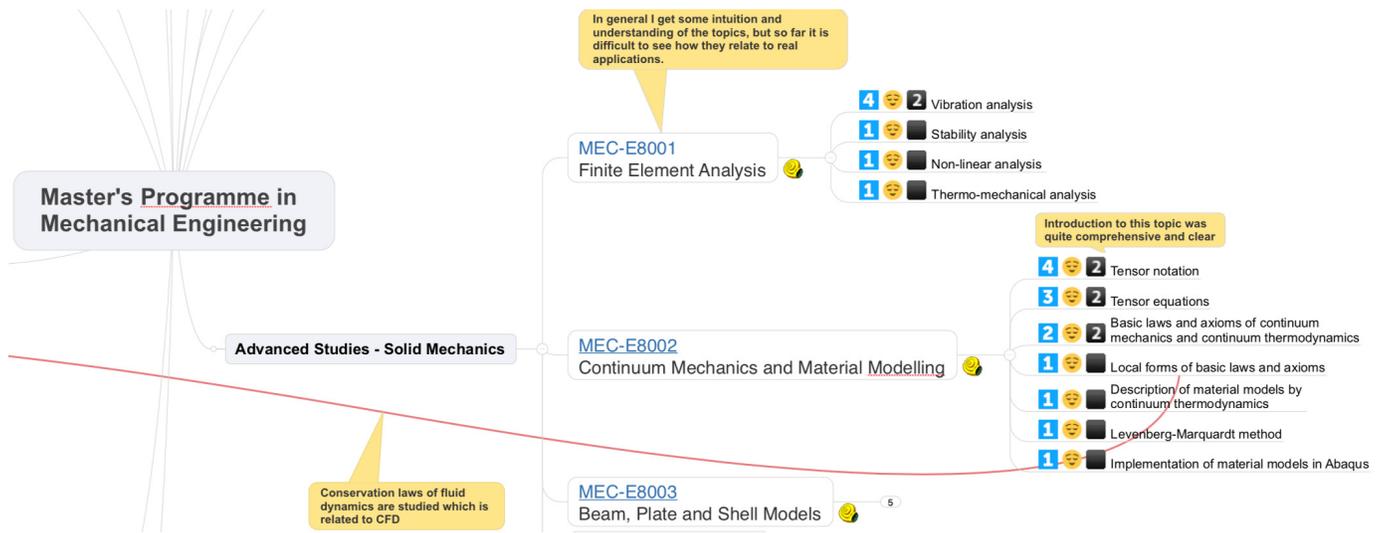


Fig. 1. The learning diary user interface.

there were any statistically significant differences between the groups before the intervention. Analyses were carried out separately for the two-group setting (diary users and control) and the three-group setting (active diary users, passive diary users and control).

A repeated measures General Linear Model (GLM) was carried out in six separate models in order to determine whether students' self-regulation (three variables) and study engagement (three variables) would change during the intervention (main effect of time), and whether their membership in a certain group had any bearing on such changes (interaction effect). In each model, the self-regulation or study engagement variable was added as a dependent variable, and group membership and intervention/time (pre- and post-tests) as independent variables (between subjects and within-subject independent variables). All of the variables were added into the models at the same time, that is, the main effect of time (intervention), as well as the interaction between group and time were investigated simultaneously. Furthermore, pairwise comparisons with the Bonferroni adjustment were conducted to further examine in which particular group the difference between the means of pre- and post-tests was significant.

Finally, one-way ANOVA was used to determine whether

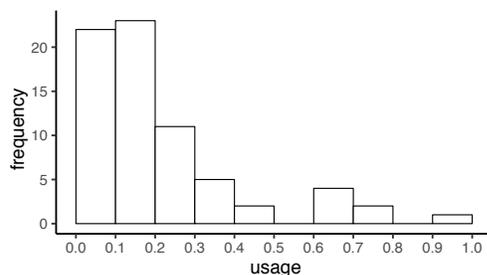


Fig. 2. A histogram of diary total usage.

there were any statistically significant differences between the groups in regard to academic achievement. Again, this was carried out separately for the two-group setting and the three-group setting. In all of the statistical analyses, the largest possible number of participants were included in each analysis.

III. RESULTS

A. Preliminary results

Descriptive statistics, internal consistencies (i.e., Cronbach's alphas) and pairwise correlations of the measures used in the study are presented in Table I. Based on found factor structures, sum variables of the different self-regulation and study engagement dimensions were created and checked for internal consistency: the Cronbach's alphas were generally above 0.6, which can be considered acceptable. An exception was the post-test measure for self-regulation of content ($\alpha = 0.56$), which can be considered satisfactory.

Independent samples T-tests and Chi-square tests were carried out to check for any initial differences between group A (diary users) and group B (control) for the pre-test, gender and age. No statistically significant differences (at 0.05 level) were found, although self-regulation of process was near ($p = 0.055$). Furthermore, one-way ANOVAs were carried out to check for any initial differences between groups in the three-group setting (A1 active diary users, A2 passive diary users, B control). Again, no statistically significant differences were found in any of the pre-test or background variables. Based on these tests, the original randomization of groups proved to be successful. Moreover, the more fine-grained grouping based on diary usage showed no differences between the groups at the beginning of the semester, and is therefore usable for further analyses.

B. Relations between diary usage, academic achievement and initial self-regulation and study engagement

Correlation analyses revealed multiple significant correlations between the self-report measures (pre-test), diary usage (log data) and registry-based achievement data (see Table I). The self-regulation and study engagement variables in particular were highly correlated. Overall, the higher the indicated self-regulation skills, the more study engagement was also reported (and vice versa). All three dimensions of engagement were positively related to each other. However, only dedication and absorption were positively correlated with GPA ($r = 0.26$ and $r = 0.27$), respectively), and only dedication indicated an increase in sum of credits ($r = 0.25$).

Self-regulation of process was positively correlated with higher self-regulation of content ($r = 0.58$), energy ($r = 0.47$), dedication ($r = 0.59$), absorption ($r = 0.48$), GPA ($r = 0.36$) and sum of credits ($r = 0.20$). Self-regulation of content was also correlated with all dimensions of engagement, but only with GPA ($r = 0.29$) in relation to academic achievement. Lack of self-regulation, on the other hand, only correlated with less dedication ($r = -0.28$).

Diary total usage had a positive correlation with sum of credits ($r = 0.33$) and GPA ($r = 0.29$) but no significant correlation with any of the self-regulation or study engagement variables.

C. Intervention effects

When comparing group A (diary users) and group B (control), the results of repeated measures GLM regarding dedication indicated a significant negative change across both groups [$F(1, 88) = 4.44, p = 0.04, \eta_p^2 = 0.05$] but non-significant interaction between the intervention and the group [$F(2, 88) = 0.14, p = 0.71, \eta_p^2 = 0.00$]. This indicates that dedication (i.e., general meaningfulness of and enthusiasm for studies) decreased significantly during the study, but the decrease was not due to the intervention. The results regarding other study engagement and self-regulation variables indicated no statistically significant changes (See Table II for complete results).

When investigating the more fine grained grouping, the results of repeated measures GLM regarding dedication again indicated a significant negative change across all groups [$F(1, 85) = 4.54, p = 0.04, \eta_p^2 = 0.05$], but this time a statistically significant interaction between the intervention (i.e., pre- and post-test) and the group as well [$F(2, 85) = 6.37, p < 0.01, \eta_p^2 = 0.13$]. In order to examine the nature of the interaction and to determine in which groups the significant differences between the mean scores of the pre- and post-tests occurred, pairwise comparisons were conducted. These demonstrated a significant difference between pre- and post-tests only within the group A2 (passive diary users) [$F(1, 85) = 16.95, p < 0.001, \eta_p^2 = 0.17$] and non-significant change in both group A1 (active diary users) [$F(1, 85) = 1.29, p = 0.26, \eta_p^2 = 0.02$] and group B (control) [$F(1, 85) = 1.24, p = 0.27, \eta_p^2 = 0.01$], indicating that the intervention had a negative effect only on the passive diary

users (see Figure 3). The repeated measures GLMs regarding other study engagement and self-regulation variables indicated no statistically significant results (See Table III for complete results).

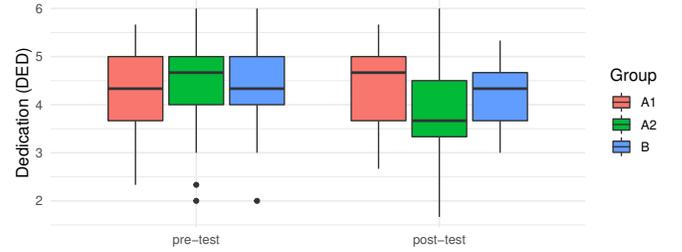


Fig. 3. Decrease of dedication for group A2 (passive diary users) was statistically significant.

D. Academic achievement

Lastly, we investigated whether the groups had differences in terms of academic achievement. The results are presented in Table IV. In the two-group setting (diary users and control), there were no statistically significant differences as determined by one-way ANOVA regarding sum of credits [$F(1, 102) = 0.10, p = 0.76$] or GPA [$F(1, 101) = 2.26, p = 0.14$].

In the three-group setting (active diary users, passive diary users and control), regarding sum of credits, there was no statistically significant difference between groups as determined by one-way ANOVA [$F(2, 101) = 1.89, p = 0.16$]. However, regarding GPA a statistically significant difference [$F(2, 100) = 4.00, p = 0.02, \eta_p^2 = 0.07$] was found. According to pairwise comparisons with the Bonferroni adjustment, the GPA for passive diary users (3.62 ± 0.80) was slightly lower compared to both active diary users ($4.01 \pm 0.49, p = 0.06$) and control group ($3.98 \pm 0.58, p = 0.06$).

IV. DISCUSSION

A. Diary usage related to achievement but not to initial self-regulation or engagement

According to Boekaerts [12], study engagement and self-regulation processes can be described as parallel paths with interconnecting side paths. Our results indeed show a high correlation between self-reported dimensions of self-regulation and study engagement. In particular, self-regulation of process and self-regulation of content were highly correlated with all dimensions of engagement. In line with previous research [3], [9], [10], higher self-regulation and study engagement (especially dedication) were generally related to higher academic achievement among students.

Surprisingly, lack of self-regulation did not correlate with academic achievement, contrary to some of the previous studies in a higher education context [26], [27]. On the other hand, there are examples where lack of regulation does not necessarily relate to lower performance. For example, Ketonen and colleagues [10] investigated university students'

TABLE I
CORRELATIONS, DESCRIPTIVE STATISTICS AND MEASURES OF INTERNAL CONSISTENCY

	PRO	CON	LOR	ENE	DED	ABS	USG	ECTS	GPA
<i>Self-regulation</i>									
Self-regulation of process (PRO)	1.00								
Self-regulation of content (CON)	0.58**	1.00							
Lack of regulation (LOR)	0.03	0.02	1.00						
<i>Study engagement</i>									
Energy (ENE)	0.47**	0.43**	-0.21*	1.00					
Dedication (DED)	0.59**	0.54**	-0.28**	0.67**	1.00				
Absorption (ABS)	0.48**	0.51**	-0.16	0.75**	0.59**	1.00			
Diary total usage (USG)	0.13	-0.03	-0.03	0.03	0.01	0.17	1.00		
Number of credits (ECTS)	0.20*	0.11	-0.16	0.15	0.25**	0.13	0.33**	1.00	
GPA (GPA)	0.36**	0.29**	-0.12	0.19	0.26**	0.27**	0.29**	0.06	1.00
<i>N</i>	104	104	104	104	104	104	70	102	101
<i>M</i>	4.48	4.21	3.69	3.40	4.32	3.54	0.21	20.25	3.83
<i>SD</i>	1.08	1.07	1.12	1.08	0.96	1.09	0.21	7.32	0.68
<i>Cronbach's alpha (pre-test)</i>	0.70	0.63	0.73	0.83	0.86	0.78			
<i>Cronbach's alpha (post-test)</i>	0.71	0.56	0.66	0.82	0.79	0.65			

* Correlation is significant at the 0.05 level (2-tailed) ** Correlation is significant at the 0.01 level (2-tailed)
Note: Correlations and descriptive statistics from the pre-test

TABLE II
REPEATED MEASURES ANOVA WITH THE ORIGINAL GROUPING

var	pre-test				post-test				within-subjects effects					
	group A (N=61)		group B (N=27)		group A (N=61)		group B (N=27)		time		time*group			
	M	SD	M	SD	M	SD	M	SD	F(1,88)	p	η_p^2	F(2,88)	p	η_p^2
PRO	4.64	1.04	4.29	1.02	4.52	1.07	4.41	0.92	0.00	0.99	0.00	1.26	0.27	0.01
CON	4.22	1.08	4.27	1.05	4.19	0.97	4.26	1.00	0.03	0.86	0.00	0.01	0.93	0.00
LOR	3.73	1.10	3.51	1.23	3.71	1.05	3.46	1.07	0.08	0.77	0.00	0.01	0.91	0.00
ENE	3.38	1.15	3.43	0.73	3.21	1.13	3.28	0.86	2.58	0.11	0.03	0.01	0.92	0.00
DED	4.34	0.94	4.40	0.85	4.09	1.03	4.22	0.65	4.44	0.04	0.05	0.14	0.71	0.00
ABS	3.45	1.02	3.81	0.98	3.45	1.01	3.79	0.95	0.11	0.74	0.00	0.00	0.99	0.00

TABLE III
REPEATED MEASURES ANOVA WITH FINE GRAINED GROUPING

var	pre-test						post-test						within-subjects effects					
	group A1 (N=26)		group A2 (N=35)		group B (N=27)		group A1 (N=26)		group A2 (N=35)		group B (N=27)		time		time*group			
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	F(1,85)	p	η_p^2	F(2,85)	p	η_p^2
PRO	4.73	1.17	4.58	0.94	4.29	1.02	4.81	0.95	4.31	1.11	4.41	0.92	0.05	0.83	0.00	1.78	0.18	0.04
CON	4.33	1.01	4.14	1.14	4.27	1.05	4.51	0.80	3.95	1.03	4.26	1.00	0.01	0.95	0.00	0.92	0.40	0.02
LOR	3.69	0.88	3.76	1.25	3.51	1.23	3.82	1.09	3.64	1.03	3.46	1.07	0.02	0.88	0.00	0.49	0.62	0.01
ENE	3.56	1.14	3.25	1.16	3.43	0.73	3.59	1.12	2.93	1.07	3.28	0.86	2.55	0.11	0.03	1.20	0.31	0.03
DED	4.26	0.93	4.40	0.96	4.40	0.85	4.44	0.86	3.84	1.08	4.22	0.65	4.54	0.04	0.05	6.37	0.00	0.13
ABS	3.74	0.99	3.28	1.02	3.81	0.98	3.76	0.97	3.22	0.99	3.79	0.95	0.10	0.75	0.00	0.08	0.92	0.00

engagement profiles, and found a profile of alienated students who, despite their lack of self-regulation and low engagement, performed relatively well. The correlation between lack of regulation and dedication (one of the dimensions of study engagement) was also found in the present study. As a result, out of the dimensions measured in the present study, particularly dedication (i.e. general meaningfulness of and

enthusiasm for studies) seemed to play a central role: it was significantly correlated with all other engagement and self-regulation variables as well as both register-based measures of academic achievement.

Interestingly, the total usage of the learning diary tool correlated positively with academic achievement but did not correlate with any of the self-regulation or study engagement

TABLE IV
COMPARISON OF THE ACADEMIC ACHIEVEMENT METRICS BETWEEN GROUPS

variable	group A total			group A1			group A2			group B total			ANOVA (A,B)			ANOVA (A1,A2,B)		
	N	M	SD	N	M	SD	N	M	SD	N	M	SD	F	p	η_p^2	F	p	η_p^2
GPA	70	3.77	0.72	27	4.01	0.49	43	3.62	0.80	33	3.98	0.58	2.26	0.14	0.00	4.00	0.02	0.07
ECTS	70	20.20	6.85	27	22.30	7.00	43	18.88	6.49	34	20.68	8.30	0.10	0.76	0.00	1.89	0.16	0.04

variables. Thus, at least in this student sample, the initial levels of the students' self-regulatory skills or study engagement did not seem to predict the rate of activity in the use of the diary tool. The dynamics between study engagement, diary usage and academic achievement are discussed further in the next chapter.

B. Divergent intervention effects depending on diary usage

Our results indicated, that when comparing the original experimental and control groups, the structured learning diary intervention had no effect on students' self-reported self-regulation or study engagement. This supports the view that the use of a learning diary alone, without any training on SRL strategies, does not improve self-regulation skills, at least as perceived by the students themselves [18]–[20]. Although no changes were found in the experimental and control groups due to the intervention, we found an overall negative change over time across all groups in one of the dimensions of study engagement, namely dedication (general meaningfulness of and enthusiasm for studies). It seems that students were generally more enthusiastic about and aware of the purpose of their studies at the beginning of the first semester than at the end of it. This is rather natural in a university context and similar effects have also been detected by Salmela-Aro and Read [11].

When investigating the intervention effects with a more fine-grained grouping (active users, passive users and control group), we found, again, some interesting results regarding dedication. During the intervention, the mean of dedication decreased in group A2 (passive diary users) and group B (control), but increased slightly in group A1 (active diary users). However, only the decrease in dedication for passive diary users was statistically significant. Among these three groups, passive diary users also had a slightly lower GPA than active diary users or the control group.

There are at least two possible ways to interpret these results. The first is that students who are generally more motivated and high-achievers are also more active users of different learning tools, such as a structured learning diary here. However, since the initial levels of study engagement did not correlate with diary usage, another possible interpretation is that among active diary users, the learning diary actually helped students to maintain their general study engagement and therefore also resulted in higher academic achievement during the semester.

On the other hand, the results can also be viewed through the model of study-related resources and demands [11], in which the demands are often perceived as higher and resources as lower among the inefficacious and burned-out students compared to the engaged students. It is acknowledged that learning diaries imply great effort for the students [17], [22] and that their motivation can decrease over time if they do not find the activity meaningful [16]. It might be the case that for some students the weekly diary exercise was too demanding, resulting in less usage and a decrease in overall study dedication and achievement. However, it is also possible that regardless of the course activities, for these students a decrease in study motivation was expected anyway and use of the diary tool simply differentiated this subgroup of students. On the other hand, it may be argued that for some students (active users group), the balance between the workload and the resources to actively use the diary tool was appropriate, and the learning diary actually prevented the otherwise likely decrease in dedication.

C. Limitations of the current study

There are some methodological limitations that should be mentioned. First, the sample for the current study was limited in size, predominantly male and consisted of students of only one discipline (Mechanical Engineering), entailing limited generalizability of the results. Second, in the post-test, the internal consistency of self-regulation of content scale was only satisfactory. Third, although hardly statistically significant, the initial self-regulation of process was slightly higher among the diary users (compared to the control group), which may have confounded some of the possible intervention effects. In addition, we did not have any information about the participants' prior achievement which could have implications for some of the findings.

One of the strengths of this study was the experimental research design, coupled with the fact that it was possible to fully randomize students to the experimental and control groups. However, the most robust results concerned the differences between the experimental subgroups (active and passive diary users) and the control group, which was partly based on artificial and retrospect segmentation of the original experimental group. Furthermore, the current study did not investigate the long-term effects of the intervention. The time span of one semester is rather short to assess changes in constructs like self-regulation and study engagement.

Regarding the measures used, the current study used self-reports as a measurement of self-regulation and study engagement. There is an ongoing scientific discussion regarding the use of self-reports versus trace data to measure learning-related constructs (see e.g. [28] for an overview). A challenge with self-reports is that students' beliefs of their regulatory skills may differ considerably from their actual regulatory behavior [29]. On the other hand, focusing only on behavior, it is difficult to capture metacognitive, affective and motivational aspects of learning [30]. Acknowledging the challenges with self-reports, they still serve as proxy measures. In our future research, the trace data of the diary tool used in this study will offer possibilities for more detailed investigations into students' SRL and engagement [23].

D. Implications

Based on our results, a structured learning diary alone does not suffice as an SRL intervention. This is in line with previous findings [18], [20] and contributes to the view that SRL interventions should be complemented with guidance on SRL strategies and their benefits. Guidance could be provided as traditional instruction but also with assistive technologies such as metacognitive prompts [31].

In addition, further investigations into why different students approach the learning diary exercise differently are needed. Since the initial levels of study engagement or SRL skills did not correlate with diary usage (or differentiate the active and passive user groups), one possible explanation is, that the weekly diary exercise is still too demanding for some students and this burden may even lead to a decrease in their overall study dedication and consequently, their academic achievement. In this sense, the intervention seemed to reveal the possible group of students at risk. It is noteworthy that from the dimensions of study engagement, it was particularly (and only) dedication that correlated with both the register-based GPA and the sum of credits. Thus, these students would either need extra support or an alternative, less demanding version of the diary exercise, since besides course performance, there might even be more wide-ranging maladaptive consequences for their academic performance. However, as the current study did not measure the effects of the intervention on academic achievement, more research is needed.

The findings also help us in the development of the structured learning diary tool. First, any unnecessary technology-related work (e.g. installing software and weekly file submissions) should be avoided. Second, writing diary entries should be seamlessly integrated into students' daily workflow. A modern solution here would be an application running in the cloud and accessible from different devices, including mobile devices. In addition, the possibilities for deeper tool integration in instructional design and pedagogical practices should be examined to increase diary tool usage.

Interesting opportunities also lie in utilizing the data emerging from the learning diary tool more broadly. While the data can be used to study students' SRL in more detail, it can also be utilized even during the learning and teaching

processes, allowing teachers to adapt their teaching 'on-the-fly' based on students weekly evaluations and reflections [23]. This formative utilization of diary data could also make the diary exercise more meaningful for the students.

V. CONCLUSIONS

In this experimental study, students used structured learning diaries for one semester. Our findings, in line with previous research, show that the diaries alone did not have an effect on students' self-regulation. When considering both previous research and our results here, it is quite clear that metacognitive tools such as a structured learning diary alone are not sufficient SRL interventions. Hence, combining tools with explicit guidance or training in self-regulation strategies and their benefits is recommended.

Moreover, our results show that learning diaries may have divergent effects depending on the student group. It appears that the majority of the participants chose not to invest time in the diary exercise for some reason. For these students, it had a negative effect on their overall study dedication. While previous research has emphasized the positive effects of learning diaries in respect of self-regulation, it is important to acknowledge that diaries may also have unwanted effects. In particular, losing the general meaningfulness and excitement vis-à-vis studying may be critical: dedication correlated positively with all self-regulation, engagement and achievement variables, hinting that a decrease in dedication may have broader negative effects for the students.

Finally, we argue that SRL intervention designs should carefully consider the demands placed upon and the resources available to students. While increasing students self-regulation skills is an important goal, it should be carried out in a way that supports students in maintaining their engagement and meaning in their studies.

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