

Effects of mobile-app learning diaries vs online training on specific self-regulated learning components.

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Abstract

Self-regulated learning (SRL) is associated with increased academic achievement and improved learning outcomes for students. Thus, it is important to find ways to improve SRL, such as through training. Face-to-face training, discipline-dependent training, and paper-and-pencil diaries are limited in the number of students they can reach. The current randomised control study implemented discipline-independent online training and novel mobile-app based diaries and tested SRL motivation and perceived strategy use in 73 University students from mixed disciplines and study mode. Results showed that participants in the combined condition (training with diaries) improved more than other conditions. Specifically, they improved on SRL knowledge, metacognitive strategies, cognitive strategies (elaboration, organisation and critical thinking), and resources management strategies (time-management and effort regulation). The present study extends previous findings, showing that positive effects can be found for SRL when a discipline-independent approach is used coupled with online training and a mobile-app based daily diary.

Key words: Self-regulated learning, online training, mobile app-based diaries, experience sampling, online learning

Effects of mobile-app learning diaries vs online training on specific self-regulated learning components

A self-regulated learner is defined as someone who monitors his/her emotions, motivation, actions, and thought processes, and actively employs learning strategies to achieve their learning goals (Zimmerman, 1986). Use of self-regulated learning (SRL) strategies are associated with increased academic achievement and improved learning outcomes for students in both traditional face-to-face settings and online environments (Broadbent, 2017; Broadbent & Poon, 2015; Richardson, Abraham, & Bond, 2012). Therefore, self-regulated learning is becoming a highly useful skill as students experience increasing freedom and responsibility regarding how, what, and when they study (Alonso-Mencía et al., 2019). Importantly, it is a skill that can be enhanced via instructional support, which gains special relevance for students with low SRL (Broadbent, Panadero, Lodge, & de Barba, *in press*). Considering the benefits and the increasing need for SRL, one line of research on how to best foster these skills in students includes the use of training and self-monitoring techniques (Bellhauser, Losch, Winter, & Schmitz, 2016; Dorrenbacher & Perels, 2016; Panadero, Klug, & Järvelä, 2016).

Interventions in self-regulated learning

Several reviews and meta-analyses have shown that the use of SRL strategies has a positive effect on learning success. Within both traditional (Richardson et al., 2012) and online learning environments (Broadbent & Poon, 2015), improved academic outcomes have been linked with several SRL strategies. These include time management, metacognition, effort regulation, critical thinking, and self-efficacy. Regardless of study mode (face-to-face or online), a high level of SRL competency is important for university students' academic success (Broadbent, 2017), particularly with trends in the sector towards more online courses which require a high level of autonomy and self-direction (Alonso-Mencía et al., 2019).

However, such a move towards online courses threatens to undermine the learning experience unless augmented with targeted resources to enhance students' SRL.

One way to improve SRL is to teach students explicitly how to employ specific SRL strategies through training (Broadbent et al., *in press*; Dignath, Buettner & Langfeldt, 2008). Research suggests that SRL training is most beneficial when it is based on a sound theoretical framework, targets all aspects of SRL, focuses on teaching multiple strategies, and is conducted over several training sessions (Dignath & Buttner, 2008; Reeves & Stich, 2011). Such training supports optimal performance by providing students with a holistic framework to evaluate and adapt their learning strategies (Cleary, Platten, & Nelson, 2008). One framework commonly used to conceptualise the process of SRL is Zimmerman's (2000) Cyclical Phases Model (Panadero, 2017). This model, grounded in social cognitive theory, describes three interdependent phases of self-regulation: forethought, performance, and self-reflection. The forethought phase involves task analysis – i.e., goal setting and effective planning strategies – as well as motivational beliefs – e.g. self-efficacy, goal orientation. The performance phase is where the execution of the task itself occurs. It involves self-control, which allows learners to focus attention and maintain interest, and self-observation, which allows for adaptive optimisation of the learning process through monitoring of progress towards a goal. The self-reflection phase takes place when there is a product to evaluate. Self-judgments occur based on self-evaluation and causal attribution, and self-reactions regarding the level of satisfaction and affective responses are made. All three phases work together to produce successful learning outcomes, and thus, are important to target during SRL-based training interventions. This model, along with all three phases, will be used in the interventions investigated here.

A second way to improve SRL is to increase students' awareness of how their current learning strategies affect their goals through the use of daily diaries (Dignath-van

Ewijk, Fabriz, & Büttner 2015; Dörrenbächer & Perels, 2016; Fabriz, Dignath-van Ewijk, Poarch, & Büttner, 2014; Schmitz & Perels, 2011). Daily diaries work by increasing planning, self-monitoring, and self-reflection. There is some empirical support for the use of daily diaries, where their use has been shown to increase self-efficacy, self-regulation, and metacognitive skills and attitude (Dignath-van Ewijk et al. 2015; Schmitz & Perels, 2011). However, typically, studies have found daily diaries to be the most efficacious when used in combination with some sort of training, rather than as a stand-alone intervention (Dörrenbächer & Perels, 2016; Fabriz et al., 2014). This makes sense as self-monitoring techniques are only likely to be successful if the user understands what successful self-regulation looks like in the first place.

Intervention delivery format

Daily diary interventions have been implemented via pen-and-paper (Dörrenbächer & Perels, 2016; Fabriz et al., 2014; Schmitz & Perels, 2011; Schmitz & Wiese, 2006), online-based platforms (Bellhäuser et al., 2016; Dignath-van Ewijk et al., 2015) or, more recently, a mobile app (Loeffler, Bohner, Stumpp, Limberger & Gidion, 2019).

Typically, SRL training interventions have been delivered at a prescribed time by a teacher in face-to-face classroom environments (e.g., Dörrenbächer & Perels, 2016; Schmitz & Wises, 2006). This type of training aims to improve students' motivation and SRL strategy use during instruction. However, face-to-face interventions are limited by the number of students that can be trained simultaneously, and by the need for students to be in the same physical location as the teacher - this time and place constraint on face-to-face training limits availability for online students.

Online, self-guided delivery of SRL training may overcome these limitations, though, to date, there have been limited evaluations of the efficacy of SRL training programs conducted online. To our knowledge, very few studies have conducted robust randomised

controlled methods that include online SRL training to higher education students alongside mobile-app based daily diaries. Bellhäuser et al. (2016) used online training to enhance 166 Mathematics students' SRL strategy use. Students were allocated to one of four groups: (a) online training, (b) online learning diary, (c) combined –including the two previous ones-, and (d) a control condition. They found that online training improved self-efficacy and SRL knowledge at post-intervention. However, SRL behaviour saw a general decrease from pre- to post-intervention assessment points for all interventions. This finding was somewhat contradicted in the trend analysis, which showed a positive improvement in SRL behaviour for the combination group. These contradictive findings leave doubt about the efficacy of online training, and this is worth exploring further. Lastly, online diaries – whether on their own or in combination with online training – did not contribute to SRL improvement.

Discipline-dependent vs discipline-independent interventions

Discipline-dependent SRL training aims to increase SRL skills and academic success within a specific content area. This type of intervention contextualises the content of the training within the particular field of study and is usually integrated into the delivery of the course (e.g., accounting, Becker, 2013; chemistry, Olakanmia & Gumboa, 2017). On the other hand, discipline-independent training focuses on learning strategies that are applicable in most learning situations, and that can be ubiquitously applied within any academic discipline (Dörrenbächer & Perels, 2016). The training is not tied to any particular course content.

Despite the differences in delivery approaches, both discipline-dependent and discipline-independent training have been found useful in face-to-face environments. Research has found discipline-dependent training improves SRL behaviours and academic outcomes (Becker, 2013; Olakanmia & Gumboa, 2017). Similarly, in a face-to-face context, discipline-independent training has shown increases in long-term educational outcomes (Bail,

Zhang, & Tachiyama, 2008). It fosters several motivational, cognitive, metacognitive, and resource management components of SRL (Dörrenbächer & Perels, 2016; Schmitz & Wiese, 2006).

Compared to face-to-face training interventions, there is less research focusing on web-based interventions, particularly content-independent approaches. Much of the SRL web-based training research has concentrated on discipline-dependent strategies (e.g. mathematics, Bellhäuser et al., 2016; educational technology, Lewis & Litchfield, 2011). Discipline-independent SRL training complements web-based training, as web-based training allows students to decide when and how they engage with the training content; thus, the training could easily be decoupled from course-related material. Future research in this area of discipline-independent web-based training is warranted particularly given the cost-effectiveness and utility such training could provide over face-to-face and discipline-dependent training.

Gaps in the Literature

The authors are unaware of any study that has implemented a randomised controlled study, that uses (a) online discipline-independent training, (b) mobile-app based discipline-independent diaries, (c) combined training and diaries condition, and with (d) a control group. The findings of Bellhäuser and colleagues are broadly consistent with prior evaluations of face-to-face administered training studies. However, contradictions are worth exploring regarding the pre/post findings. Null findings for the benefits of diary use are inconsistent with prior studies demonstrating that diaries as a stand-alone intervention can increase SRL (Dignath-van Ewijk et al., 2015; Loeffler et al., 2019). We note that reported diary analyses in Bellhäuser et al. (2016) focus on actual engagement in SRL behaviours (SRL actual use measured after study session).

In contrast, Dörrenbächer and Perels (2016), who used paper-and-pencil diaries, reported separate findings for planning (intended SRL use measured before study session), action, and reflection phases of SRL (actual SRL use measured after study session). They found improvements for both planning and action stages of SRL for individuals receiving training with diaries. While participants in the diary condition (with no training) exhibited improvements for task strategies but declines over time in self-efficacy, goal setting, and handling stress. Thus, the impact of diary notification may depend on one's current SRL ability or the way SRL is operationalised. With existing SRL ability, the diaries may serve as a prompt to engage in these skills. However, without such skills, intent may not match actual behaviour, and may instead lead to increased negative mood states and diminished use over time due to low self-efficacy (Dörrenbächer & Perels, 2016). However, these authors did not include a training condition (without diary) to compare the efficacy of training alone vs training with a diary component. Another possibility for the difference in findings may be related to the delivery mode of the diaries. Bellhäuser et al. (2016) used online delivery, and Dörrenbächer and Perels (2016) used paper-and-pencil methods. It is possible that alternative delivery modes, such as a mobile-app as used by Loeffler et al. (2019), might find different results. As such, the added benefit of diaries beyond training alone warrants further attention.

We also note that Bellhäuser et al.'s (2016) study used discipline-dependent SRL training. The advantage of such an approach is that the SRL strategies can be tailored to the content the student is studying. However, there is some question about the generalisability of such an approach beyond the context targeted in training (Broadbent et al., *in press*). It remains unclear whether a discipline-independent online training program for SRL can achieve similar or greater benefits to the ones observed by Bellhäuser et al. (2016). As such, the present study used such an approach to investigate this matter.

Finally, there is a tendency to evaluate the effects of different interventions in SRL using the total scores that sum up different strategy use scales. For example, the Motivated Strategies for Learning Questionnaire (MSLQ) which is the most used SRL measurement instrument (Broadbent & Poon, 2015) is usually analysed only at the second-order scale without reporting in details the first order scales. For that reason, here we will arrange the paper around the second-order scales (perceived strategy use and motivation) but reporting the first-order scales ones too. This way, our level of understanding of the intervention effects will be deeper.

Aims, Research Questions, and Hypotheses

The current study aim is to evaluate the effects of an SRL online training to mobile app-based learning diary on SRL, intended SRL use, actual SRL use, and affect. Our study replicates and extends the findings of Bellhäuser et al. (2016) by teaching discipline-independent SRL skills and using mobile-app based diaries. This study asks the following research questions:

RQ1: Which of the four interventions lead to greater improvement in perception of SRL strategy use (RQ1a) and SRL motivation (RQ1b)?

RQ2 Is it more effective to implement the mobile app-based diary alone or combined with online training for improved SRL?

Based on the findings of Bellhäuser et al. (2016), it is hypothesised that:

H1: The combined condition will show the highest positive effects in both perception of SRL strategy use and motivation, followed by the online training (alone) and diaries (alone) outperforming the control condition.

H2: The combined group (training plus diary) will exhibit greater improvement in (a) intended SLR use, (b) actual SRL use, and (c) changes in affect.

Method

Participants

The present study final participant numbers after attrition comprised 73 students currently studying at Deakin University. The majority were female (68.5%), ranging in age from 17-58 years old ($M = 25.90$; $SD = 8.02$), who were on-campus students (75.3%) in their first year of study (43.8%), and were more likely to be studying courses from nursing, psychology, health sciences, or sports and nutrition science (59%) followed by degrees related to business and law (15%).

The final numbers for each condition are as follows. The online training condition comprised 16 participants aged 18-42 ($M = 24.25$, $SD = 6.42$). The mobile app-based diary condition consisted of 21 participants aged 18-48 ($M = 26.76$, $SD = 8.30$). The combined condition featured 14 participants aged 17-58 ($M = 29.71$, $SD = 11.70$). The control condition consisted of 22 participants aged 18-38 ($M = 23.86$, $SD = 5.01$). The four groups of the intervention did not significantly differ on any demographic variables: age ($F(3,69) = 1.90$, $p = .137$), gender ($\chi^2 = 1.46$, $p = .692$), year of study ($\chi^2 = 3.87$, $p = .276$), study mode ($\chi^2 = 2.95$, $p = .399$), or Faculty of study ($\chi^2 = .82$, $p = .844$).

The project had a dropout rate of 68.8% (original sample size $n = 234$), whereby students completed the baseline questionnaire but then did not engage any further with the study (e.g., they did not start any training or diaries). To evaluate potential bias from attrition due to differences between completers and non-completers, we compared them on a range of measures. Completers did not differ on age, gender, year level, or study mode to non-completers ($p > .05$). There were no significant differences in pre-intervention questionnaire scores between groups except completers were more confident ($t_{(232)} = 2.16$, $p = .03$) and used more elaboration ($t_{(216.01)} = 2.57$, $p = .01$) and metacognitive ($t_{(202.69)} = 2.56$, $p = .01$) learning strategies than non-completers.

Materials

Demographics. Demographic data included age, gender, Faculty, and year of study.

Declarative knowledge test. Declarative knowledge of SRL was assessed via 25 multiple-choice questions targeting students' understanding of the SRL concepts and strategies covered in training content. Items were developed by the authors and offered four possible choices with one correct answer. Higher scores indicate higher levels of declarative knowledge. The maximum score was 25 (see Appendix 1).

Motivated Strategies for Learning Questionnaire (MSLQ). Self-regulated learning strategies and motivations were obtained using the Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1991). The MSLQ has established reliability and validity, and consists of 81 items scored on a seven-point rating scale, ranging from 1 to 7 with defined end points of "not at all true of me" and "very true of me". Subscales include motivation components such as intrinsic motivation (Cronbach's α pre = .74, post = .78) and extrinsic motivation (Cronbach's α pre = .63, post = .79), control beliefs (Cronbach's α pre = .64, post = .84), test anxiety (Cronbach's α pre = .82, post = .85), task value (Cronbach's α pre = .86, post = .92), and self-efficacy (Cronbach's α pre = .93, post = .92); metacognitive strategies which is a single subscale covering planning, goal setting, task analysis, and self-monitoring (Cronbach's α pre = .76, post = .84); cognitive learning strategies such as rehearsal (Cronbach's α pre = .55, post = .63), elaboration, (Cronbach's α pre = .74, post = .87) organisation (Cronbach's α pre = .68, post = .78), and critical thinking (Cronbach's α pre = .85, post = .87); and resource management strategies such as effort regulation (Cronbach's α pre = .77, post = .79), time and environment management (Cronbach's α pre = .81, post = .81), peer-learning (Cronbach's α pre = .54, post = .70), and help-seeking (Cronbach's α pre = .77, post = .80). Higher scores indicate higher perceived strategy use.

Mobile app-based Learning diary. The mobile app-based learning diary was inspired by previous studies (Bellhauser et al., 2016; Dorrënbächer & Perels, 2016; Schmitz & Weise, 2006) but developed by the authors. It was delivered through the Instant Survey smartphone app platform (Instant Survey: Richardson, 2015). This content was delivered via an app instead of pen-and-paper or web-based survey because (a) mobile app-based diaries offer students more access to the tool and thus enable them to complete the diary intervention anytime, and at any place they deem appropriate; (b) app-based diaries offer a novel way to engage users' attention, which then helps encourage the adoption of intended learning behaviour; and (c) the mobile app has a reminder that goes off twice daily to alert the student to fill out the diary. Diaries consisted of two parts: 1) before study session (15 questions), and 2) after study session (24 questions), that was completed daily for 21 days.

Before Study Session. First, learners were asked whether they planned to study on that day. If yes, they were asked about their intention to use SRL strategies via items covering learning strategies such as planning, goal setting, task analysis, and motivations, as well as about their affect (positive and negative) levels. If no, they did not complete any more of the survey at that timepoint.

After Study Session. First, learners were asked to report their actual use of SRL strategies during the study session (see Appendix 2). Second, they were also asked about their affect (positive and negative) levels.

Online training. The online training was designed by the authors, and comprised of three 60-90-minute sessions, spaced out over 21 days, delivered through the learning management system, Schoology.

Each session focused on a different phase of the SRL process (See Appendix 3).

- Session 1 Forethought: SMART goals –i.e. Specific, Measurable, Attainable, Realistic and Timely-, planning, time management;

- Session 2 Performance: dealing with distractions, procrastination, cognitive and metacognitive strategies; and
- Session 3 Reflection: attribution, frame of reference and reflection, self-motivation, self-rewarding.

After each lesson, participants filled in a short evaluation form. Questions included the actual duration of the lesson, the novelty of the content on a six-point rating scale from “already known” to “novel”, the perceived usefulness of the strategies taught on a six-point rating scale from “not useful” to “useful”, and an overall grade for the quality of the lesson (1 = very good; 2 = good, 3 = satisfactory, 4 = sufficient, 5 = deficient, 6=insufficient). See Appendix 4 for example content from the training.

Design

This study utilised a randomised, controlled study design. The following four conditions were created to test which intervention was most successful at improving self-regulated learning:

1. Online training condition: learners only completed three 60-90-minute sessions, spaced out over 21 days.
2. Mobile app-based diary condition: completed daily by learners for 21 days.
3. Online training with mobile app-based diary condition (combined condition): learners only completed three 60-90-minute sessions, spaced out over 21 days and completed daily diaries over the same time frame.
4. Control condition: learners did not engage in any intervention.

Table 1 shows the material used in each condition. See descriptions in the Material section for more details.

Table 1

Materials used in each condition

	Knowledge Test (pre/post)	MSLQ (pre/post)	Online training	Daily Diaries
Intervention Conditions				
Online training condition	x	x	x	
Mobile app-based diary condition	x	x		x
Online training with mobile app-based diary condition (combined condition)	x	x	x	x
Control condition	x	x		

Procedure

Recruitment occurred via online advertisement in various undergraduate classes, student run University Facebook groups and by word of mouth. After giving consent, participants completed the demographic questionnaire, declarative knowledge test, and MSLQ as a baseline assessment point. Participants who decided to continue to the intervention were then randomly assigned to one of three intervention groups or the wait-list control condition. The intervention phase lasted 21 days regardless of condition assigned. The online training and the app-based diary conditions were delivered as presented earlier. In the condition with the combination, participants completed both diaries and online training concurrently. Lastly, participants in the control condition were not given access to the training or diaries during the 21 day intervention period. After the intervention, all participants were directed to a post-test online questionnaire consisting of the SRL declarative knowledge test and MSLQ. Control participants were also given access to the

resources if requested. The present study was approved by the Deakin University ethics board.

Data Analyses Plan

All descriptive and group-difference analyses were conducted using IBM SPSS 25. Group differences on the demographic variables were assessed using chi-square tests (categorical variables) and ANOVAs (continuous variables). Baseline differences between the groups on SRL constructs were examined first, before conducting a series of ANCOVAs for each of these SRL variables at post-intervention, with baseline scores on the same variable treated as a covariate. Significant group effects for the sample as a whole were followed up with paired comparisons between each of the groups separately. Effect sizes for these ANCOVAs were reported as eta square values, and interpreted using Cohen's (1988) guidelines: .01 - .05 = small effect, .06-.13 = moderate effect, $\geq .14$ = large effect.

Comparisons of diary data between the mobile app-based diary condition and the diary plus online training condition were conducted in Mplus version 8 (Muthén & Muthén, 2017) using multilevel modelling. Six models were run, representing negative and positive affect and intended SRL use as reported prior to the study, as well as affect and actual SRL strategy use reported following study. These dependent variables were regressed onto a time variable, to reflect the change in these outcomes from start of the study period to the end, as well as a grouping variable (0 = diary condition, 1 = combined condition), and the interaction between time and group. This interaction term was used to test the hypothesis that greater improvements in these outcomes over time would be found for the combined condition. Cohen's *d* values were calculated to quantify the effect size for this interaction term. Covariates of stress and minutes of study (planned for the pre-study assessment, and actual

and productive minutes of study for the post-study assessment) were included as potential time-varying confounds in the estimation of affect and SRL engagement.

Results

Descriptive statistics and preliminary analyses

Descriptive statistics are given in Table 2. The four groups did not differ on baseline scores for the SRL constructs: knowledge ($F(3,69) = 0.60, p = .616$), intrinsic motivation ($F(3,69) = 1.96, p = .128$), extrinsic motivation ($F(3,69) = 1.41, p = .248$), task value ($F(3,69) = 0.78, p = .512$), control belief ($F(3,69) = 0.44, p = .725$), self-efficacy ($F(3,69) = 0.11, p = .957$), test anxiety ($F(3,69) = 0.43, p = .734$), rehearsal ($F(3,69) = 1.22, p = .310$), elaboration ($F(3,69) = 0.33, p = .804$), organisation ($F(3,69) = 1.17, p = .327$), critical thinking ($F(3,69) = 0.38, p = .768$), metacognition ($F(3,69) = 0.36, p = .780$), time management ($F(3,69) = 0.05, p = .985$), effort regulation ($F(3,69) = 0.02, p = .997$), peer learning ($F(3,69) = 0.27, p = .849$), or help seeking ($F(3,69) = 0.06, p = .982$). Hence, despite differences in sample size at baseline across groups, randomisation successfully ensured the groups were equivalent in baseline characteristics prior to the intervention phase.

User ratings from the two conditions that received online training were positive. Both groups rated the quality ($M = 5.14, SD = 0.88$ for the online training condition, and $M = 5.43, SD = 0.45$ for the combined condition; possible score range = 1 to 6) and usefulness of the intervention content as high ($M = 3.52, SD = 0.54$ for the online training condition, and $M = 3.50, SD = 0.45$ for the combined condition; possible score range = 1 to 4). The novelty rating for the intervention was around the midpoint ($M = 2.43, SD = 0.53$ for the online training condition, and $M = 2.10, SD = 0.45$ for the combined condition; possible score range = 1 to 4), suggesting participants were already somewhat (though not strongly) familiar with

the techniques provided in the intervention. None of these ratings differed significantly across the two groups (all $t_s < 1.39$, $p_s > .188$).

Further, compliance was strong for diary completion and use of training modules. Across all participants, average diary completion was 27.23 surveys ($SD = 12.80$). The diary condition completed more diary entries ($M = 27.76$, $SD = 13.18$) than the diary plus training condition ($M = 26.43$, $SD = 12.65$), but this difference was non-significant; $t(df=33) = 0.30$, $p = .768$. Both the training and combined groups had good compliance, viewing an average of 2.75 ($SD = 0.58$) and 2.43 ($SD = 1.16$) modules out of a maximum of 3 modules. The two groups did not differ significantly in number of modules completed; $t(df=28) = 0.98$, $p = .335$.

Main analyses

RQ1: Which of the four interventions lead to greater improvement in perception of SRL strategy use and SRL motivation?

ANCOVAs (controlling for baseline scores on the SRL variables) revealed significant group effects for knowledge, organisation, critical thinking, metacognition, and time management at post-intervention. Group differences at post-intervention were non-significant for all remaining SRL variables. See Table 3.

Figure 1 shows the mean differences across groups for all SRL constructs. Post-hoc comparisons confirmed significantly greater improvements on knowledge for the online training ($p = .005$, Cohen's $d = .48$), combined ($p = .014$, $d = .42$), and control conditions ($p = .033$, $d = .33$) relative to the diary condition which experienced reduction in knowledge scores at post-intervention.

Table 2.

Group Differences for Modelled Variables.

Variables	Control (<i>n</i> = 22)				Diary (<i>n</i> = 21)				Online training (<i>n</i> = 16)				Combined (<i>n</i> = 14)			
	Pre		Post		Pre		Post		Pre		Post		Pre		Post	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Knowledge	17.18	3.83	18.18	3.90	18.10	3.45	16.90	5.08	18.25	2.79	19.81	2.66	18.64	3.52	19.79	2.83
Intrinsic	5.15	.98	5.14	.95	5.24	1.05	5.04	1.14	5.86	.89	5.83	.90	5.55	.96	5.48	1.08
Extrinsic	5.72	1.01	5.24	1.20	5.49	1.11	5.43	1.01	5.08	1.09	5.05	1.10	5.18	.89	4.98	1.46
Task value	5.86	.86	5.73	.90	5.87	.92	5.71	1.07	6.10	.83	6.26	.87	6.23	.71	5.90	.98
Control	5.89	.72	5.52	1.01	5.89	.94	5.75	.98	6.14	.77	6.23	.71	6.05	.70	5.91	.87
Efficacy	5.35	1.34	5.27	1.11	5.40	.95	5.27	1.15	5.30	.82	5.50	.92	5.19	1.29	5.62	.98
Anxiety	3.78	1.59	3.62	1.34	4.28	1.35	3.83	1.36	3.95	1.59	3.98	1.49	4.13	1.57	4.04	1.78
Rehearsal	4.49	1.26	4.44	1.00	3.94	1.06	4.23	1.29	4.34	1.13	4.45	1.07	3.88	1.24	4.70	.94
Elab	5.12	1.01	5.18	1.13	5.09	1.06	5.21	1.26	5.39	1.01	5.67	.92	5.11	.67	5.69	.96
Org	4.61	1.26	4.74	1.33	4.80	1.19	5.38	1.17	4.88	1.22	4.95	1.28	4.11	1.30	5.45	.82
Critical	4.18	1.35	4.38	1.10	4.21	1.62	4.43	1.64	4.49	1.07	5.03	.97	3.97	1.10	5.07	.95
Metacog	4.41	.92	4.57	.92	4.34	.96	4.56	.88	4.52	.92	5.09	.95	4.18	.84	4.92	.65
Time	4.73	1.21	4.75	1.18	4.63	1.20	4.72	1.09	4.61	1.09	4.73	.94	4.69	.99	5.38	.94
Effort Reg	4.92	1.52	4.94	1.29	4.94	1.31	4.98	1.14	4.86	1.22	5.27	1.06	4.86	1.37	5.52	1.12
Peer Learn	2.88	1.11	3.35	1.15	2.97	1.44	3.56	1.72	2.85	1.32	3.21	1.60	2.60	.94	3.45	1.47
Help Seek	3.31	1.37	3.51	1.18	3.40	1.46	3.74	1.67	3.36	1.46	3.94	1.61	3.21	1.22	3.70	1.50

Note. Intrinsic = intrinsic goal orientation, Extrinsic = extrinsic goal orientation, Efficacy = self-efficacy, Elab = elaboration, Org = organisation, critical = critical thinking, Metacog = metacognition, Time = time management, Effort reg = effort regulation, Peer learn = peer learning, Help seek = help seeking.

Table 3

Results of ANCOVA for Knowledge Test and MSLQ Subscales

	<i>F</i> (3,69)	<i>p</i>	η^2
Knowledge Test	3.62	.017	.138
SRL Motivation			
Intrinsic goal orientation	0.61	.608	.026
Extrinsic goal orientation	0.39	.762	.017
Task value	1.23	.305	.052
Control	1.52	.217	.063
Self-efficacy	1.68	.179	.069
Anxiety	0.57	.636	.025
SRL Strategies			
Rehearsal	1.07	.368	.045
Elaboration	1.90	.139	.077
Organisation	4.02	.011	.150
Critical Thinking	3.22	.028	.124
Metacognition	3.07	.034	.119
Time Management	2.79	.047	.109
Effort Regulation	2.32	.083	.093
Peer-Learning	0.68	.569	.029
Help-Seeking	0.41	.748	.018

*Statistics for condition differences at post-intervention are given. In bold *p* values below .05.*

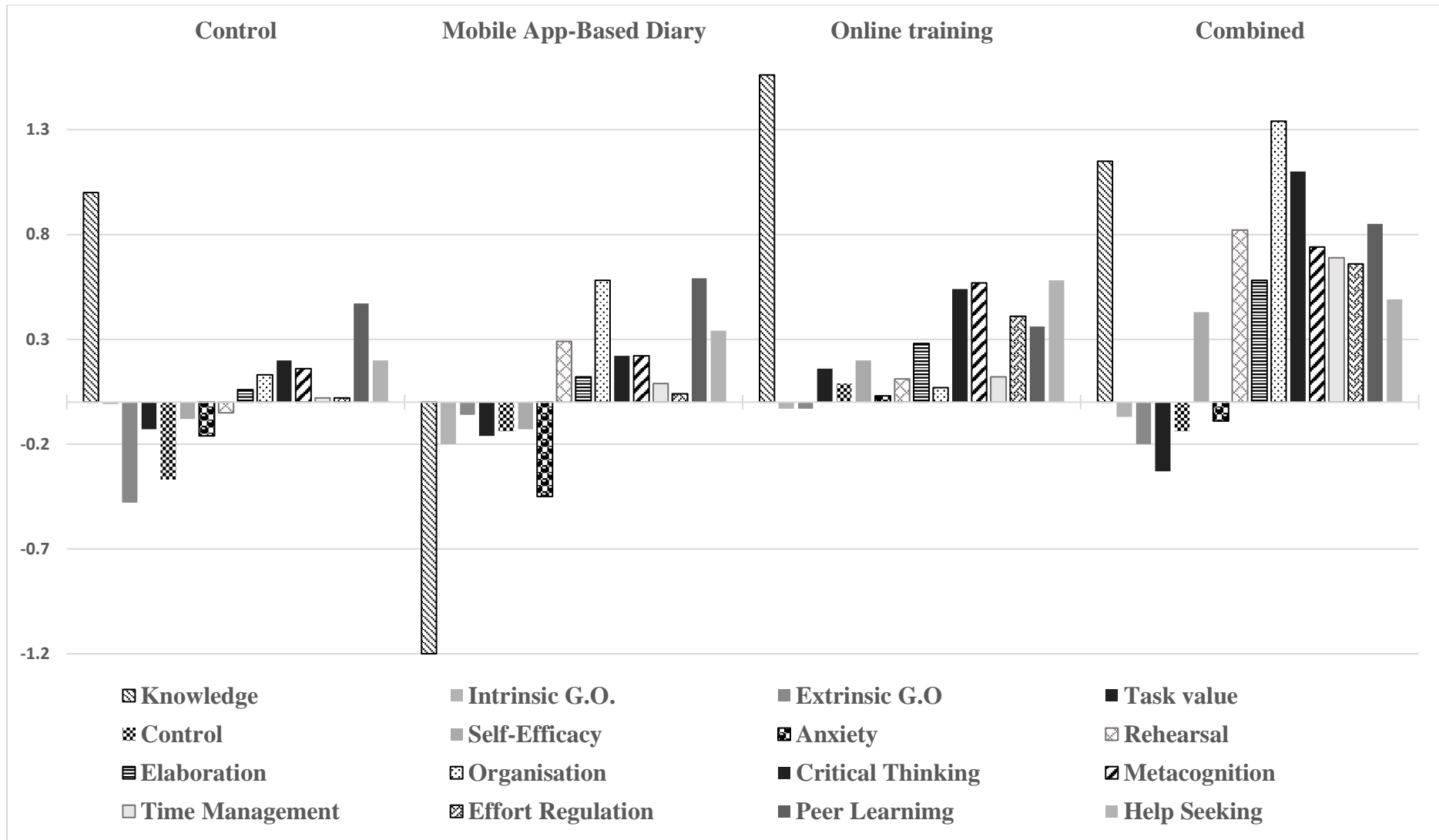


Figure 1. Mean differences across groups for all SRL constructs

Perceived SRL strategy use

The combined condition reported greater improvement in organisation than the online training condition ($p = .008, d = .50$) or control condition ($p = .003, d = .52$). Greater improvements in critical thinking were observed for the combined condition relative to the mobile app-based diary condition ($p = .012, d = .44$) and control ($p = .009, d = .45$) groups. Improvements in metacognition were greater for the training condition relative to the control condition ($p = .034, d = .35$), and the combined condition relative to the mobile app-based diary condition ($p = .038, d = .33$) and control ($p = .024, d = .38$) groups. Significantly greater improvements in time management were observed for the combined condition than online training ($p = .029, d = .41$), mobile app-based diary condition ($p = .018, d = .41$), and control ($p = .011, d = .44$) groups. Finally, the combined condition reported significantly greater improvements in effort regulation than the mobile app-based diary condition ($p = .033, d = .37$) and control ($p = .026, d = .38$) conditions. Group differences were not significant for rehearsal, peer learning or help seeking.

SRL motivation

The online training condition experienced greater improvement in the control beliefs than the control condition ($p = .038, d = .34$), while the combined condition reported greater improvement than the control condition for elaboration ($p = .030, d = .37$). Group differences were not significant for intrinsic or extrinsic motivation, task interest, or self-efficacy.

The combined condition was superior to one or more groups on the measures of knowledge, elaboration, organisation, critical thinking, metacognition, time management, effort regulation which supports hypothesis one (H1). Additionally, the online training condition was superior to the control condition for the development of control beliefs and metacognition only, which also supports H1. However, the mobile app-based diary condition

did not significantly outperform the control condition on any measure, a finding that runs against H1.

RQ2 Is it more effective to implement the mobile app-based diary alone or combined with online training for intended SRL use, SRL actual use, and affect?

Intended SRL use (measured before study session). The average level of intended SRL use did not significantly change over the course of the intervention for the sample as a whole ($b = .004, p = .599$). Nevertheless, there was a significant moderated effect by condition ($b = .022, p = .037$, Cohen's $d = .43$). Post hoc testing demonstrated that intended SRL use did not significantly change over time for the diary condition ($b = -.002, p = .850$), but did significantly increase for the combined condition ($b = .016, p = .035$, Cohen's $d = .80$).

Actual SRL use (measured after study session). The time trend was significant for the sample as a whole ($b = .021, p = .027$), suggesting that the actual use of SRL strategies increased across the intervention phase. Additionally, this time trend was moderated by condition ($b = .024, p = .009$, Cohen's $d = .60$). Post-hoc testing revealed that the combined condition reported greater actual SRL use towards the end of the intervention phase ($b = .023, p < .001$, Cohen's $d = 2.04$), while the diary condition did not significantly differ in its use of SRL strategies across the intervention phase ($b = .006, p = .467$).

Changes in affect (measure both before and after study session)

Before Study Session. Over the course of the intervention phase, the reported level of positive affect before learning marginally significantly improved over time for the sample as a whole ($b = .014, p = .053$). The magnitude of this change in positive affect did not significantly differ across groups ($b = .007, p = .288$). Regarding the reported level of negative affect, this did not significantly change for the sample overall ($b = -.013, p = .305$),

nor did the level of change significantly differ across the diary condition and combined condition ($b = -.008, p = .373$).

After Study Session. Neither positive nor negative affect ratings post-study changed significantly over time for the sample as a whole; ($b = -.007, p = .495$), and ($b = -.008, p = .483$), respectively. Group did not significantly moderate this time trend for positive affect ($b = .023, p = .232$) or negative affect ($b = .023, p = .214$).

These findings mostly confirm our second hypothesis (H2): the combined condition would exhibit greater improvement in intended SRL use, actual SRL use, and an increase in positive affect during the intervention phase. No significant differences were found for negative affect.

Discussion

We aimed to compare the effects of online SRL training vs. mobile app-based learning diaries. This led to an experimental design with four conditions (control, mobile-app based diary, online training, and combined). The dependent variables were SRL motivations and strategies measured via MSLQ, intended SRL use, actual SRL use, and affect measured in the diaries. Our design follows that used by Bellhäuser et al. (2016), except that the present study used discipline-independent online training, while theirs used discipline-dependent, and we used a mobile-app based daily diary, and they used online diaries. In general, we found support for most hypotheses.

Exploring the effects of online training vs. mobile-app based learning diary

In the first research question (RQ1), we compared the four conditions to conclude which SRL intervention had better effects on SRL motivations and perceived strategy use. Compared to the other conditions, the combined condition (learning diary plus online training) showed the most overall improvement in perceived SRL strategy use. Additionally, the online training condition (even without learning diaries) surpassed the control condition

in some SRL strategies. While the two previous results are in accordance with our hypothesis, unexpectedly, the learning diary condition did not outperform the control condition. No condition improved students' SRL motivations, except training alone, which improved control beliefs. Lastly, user ratings from the two conditions that received online training were positive. Both groups rated the quality and usefulness of the intervention content as high. The novelty rating for the intervention was around the scale midpoint, suggesting participants were already somewhat (though not strongly) familiar with the techniques provided in the intervention.

Which of the four interventions lead to greater improvement in perception of SRL strategy use?

Previous SRL research has tended to aggregate SRL strategies into a single or reduced number of scales. This makes it difficult to assess the impact of the intervention on specific SRL strategies. As stated by Panadero (2017, p. 24) “...*more fine-grained studies should also be conducted to understand how the specifics of SRL work*”. The current study investigated strategies individually. Our study found that participants in the combined condition improved on cognitive (elaboration, organisation and critical thinking), metacognitive, and resources management (time-management and effort regulation) strategies more than other conditions. This suggests students who had training combined with a diary learnt to manage themselves and their surroundings during learning tasks, avoided distractions, handled procrastination, and stayed on task. Further, they could use strategies to improve comprehension and retention of learning, as well as increased planning and goal setting, self-monitoring during learning, and checking and correcting learning strategies, including adjusting and modifying cognitive activities as they learnt. Further, as metacognitive strategies only improved in conditions exposed to training, improved metacognition was likely a direct result of the training.

While not all strategies were found to improve, time management, effort regulation, metacognition, and critical thinking strategy use have previously been positively linked to grade in both on-campus and online students (Broadbent & Poon, 2015; Richardson et al., 2012), with elaboration also correlated with grade in on-campus cohorts (Richardson et al., 2012). Further, unlike Bellhäuser et al. (2016) who found a general decrease in strategy use after training, this study found that a discipline-independent online training intervention can improve self-regulation in students regardless of their course discipline. Perhaps, general instruction about each strategy and how to use it effectively in the current study was more beneficial to students than learning it within a specific discipline, because the strategies could be more easily transferred to everyday use and other learning situations.

The use of diaries did not improve any learning strategies compared to the control condition or any other condition. This possibly indicates that self-monitoring alone, or self-monitoring delivered through a mobile app, is not a useful intervention for improving SRL. That is, it appears that awareness, through repeated questioning, is not enough to elicit plans to use SRL nor actual engagement in SRL. In one sense, this finding is not surprising because the use of self-monitoring techniques can only work as an intervention if the user already knows how to self-regulate. Previous studies have found support for diaries (e.g., Dignath-van Ewijk et al., 2015; Loeffler et al., 2019). However, both studies had instruction or feedback embedded into the learning diaries that may have acted as a form of training. Dignath-van et al. (2015), for example, had ‘study advice’ with the learning diaries where there were instructions about how to plan and set priorities, monitor, self-motivate, and reflect on failures. Loeffler et al.’s (2019) diary intervention contained prompting and personalised near real-time feedback, which may have acted as a form of training.

Which of the four interventions led to greater improvement in SRL motivation?

The current study explored several motivational variables, including intrinsic and extrinsic goal orientation, self-efficacy, task value, task interest, and test anxiety. None of these significantly improved for any condition, except online training. Online training had a significant improvement in control beliefs, indicating that, after training, participants believed their efforts could make a positive difference to their studies. The same was not found for the combined condition. These findings possibly show that merely learning about motivation, and even being asked about it daily, is not enough to improve these variables. Alternatively, the findings may instead indicate that change in motivation may take longer to emerge, and hence longer follow-up is needed. For instance, if the change in self-efficacy requires sustained and improving study results, then that would take time to emerge as opportunities to use SRL grow.

Is it more effective to implement the mobile app-based diary alone or combined with online training for intended SRL use, SRL actual-use, and affect?

Trend analysis supports the findings found with the pre/post questionnaires. The combination of online training with self-monitoring showed a positive linear increase in SRL intention over time. While SRL use also increased over time, post-hoc testing revealed that the combined condition reported greater SRL actual use towards the end of the intervention phase. These findings suggest that training had a cumulative effect, such that for students to get the most benefits, they needed to complete all three sessions. These findings are in line with Bellhäuser et al.'s (2016) trend analysis findings. However, it is in contrast to their internally conflicting results they found between the pre/post questionnaires and the diary trend analysis. They argued that these differences might occur because the diaries measured states and their pre/post questionnaire measured traits. As we used the MSLQ, explicitly designed to be dynamic and contextually bound (Duncan & McKeachie, 2005), both of the

measures we used were likely capturing state elements. While Bellhäuser et al. (2016) also used questions from the MSLQ in their pre/post measures, we are unable to comment on whether they were modified sufficiently to capture students' learning traits. Lastly, in line with the pre/post questionnaire findings, diaries alone did not show any improvement in SRL intention or use.

Neither intervention exhibited a change in negative affect before or after learning over time, and both groups had an increase in positive affect prior to learning over time, at least indicating that neither the training nor diary detrimentally affected how students were feeling. This is somewhat surprising because one might expect that prompted reflection on SRL use without adjoining training resources might increase negative affect.

Limitations

The present study has several key limitations. First, the long-term effects of the interventions were not investigated. In light of findings by Dorrënbächer and Perels (2016) showing that face-to-face training improved SRL up to eight weeks post-intervention, null findings in the present study may be due to our short follow-up period. Future research should incorporate time points after the intervention to determine the trajectory of SRL competency following training.

Second, there was no assessment of performance in subjects to show the predictive value of improving SRL. Of course, there are practical limitations, such as students in the present sample not being in one single program of study, making this infeasible to meaningfully compare performance across participants. Even so, we argue that it is meaningful to look at changes in SRL since these are well-established predictors of performance. Uniformity in this measure in the present study across all participants facilitated evaluation of this as an outcome of intervention.

Third, our study may not represent all students. The university from which participants were recruited has a reasonably large proportion of mature age students, and hence the age range of participants in the present study may differ from other institutions. The impact of age on baseline self-regulated learning levels and capacity to improve from the current intervention warrants further attention in a replication study. Further, there was a large drop-out after the baseline measurement. This may signal that students with low self-regulation are insufficiently motivated to participate in a self-guided study about self-regulation. More direct efforts to enhance self-confidence in ability to learn may facilitate stronger through-put from baseline survey completion to participation in the intervention phase in future studies. A further issue with respect to representativeness is that the majority of our participants were female (68.5%). While this figure is in line with the gender balance of the University (61% Female; Deakin University Strategic Intelligence and Planning Unit, 2018), our findings may not equally represent all students. Lastly, it should be noted that the MSLQ only measures learners' perceptions of strategy use, and cannot provide information on how successfully the learner implements the strategy.

Educational implications

This study has shown that online training and mobile-app based diaries can improve students' abilities to self-regulate their learning. Importantly, the discipline-independent nature of this intervention, the focus of fostering SRL during everyday learning situations, and the scalability of this intervention due to its online design, makes this intervention potentially applicable to all learners. Understandably, a program that can increase SRL regardless of discipline and location warrants further exploration — particularly looking at the timing of the training and the duration of the intervention. For example, if training and diary effects still occur when completed across a few days rather than two weeks, there may be stronger participant retention.

Based on present findings, this study has implications for practice, showing that students' SRL can be fostered independently of their day-to-day study, and may be embedded broadly within a student's course regardless of discipline. Further, this study shows that knowledge of SRL strategies alone is not enough; the application of successful learning strategies may entail understanding when to apply these skills and the ability to chart one's progress towards learning goals. As such, it may be beneficial for any training given to students to be reinforced with diaries in order to have a positive influence on SRL. As discussed in Broadbent et al. (*in press*), there are six key challenges in developing students' self-regulated learning in online learning environments. The intervention reported in this study targets three of these challenges: we have targeted all SRL phases rather than segments (Challenge 3), with a domain non-specific intervention (Challenge 4), and computer-led intervention rather than being led by a researcher or teacher (Challenge 5). As previously mentioned, future research in this area should also target the effects of the intervention on learning and performance (Challenge 2), and the capacity of the technology-based SRL interventions to enhance the students' independent development of SRL (Challenge 6).

Conclusion

Findings are broadly consistent with previous studies in showing that online training is feasible, accepted by participants, and leads to improvements in SRL in a short period of time. Findings are also consistent in showing that diary alone does not improve SRL use, which is counter to some earlier findings. Importantly, the present study extends previous findings. We have shown that positive effects can be found for SRL when a discipline-independent approach is used coupled with online training and a mobile-app based daily diary. What is needed now is a longer-term follow-up to see whether improvements are sustained. Further consideration should be given to improving motivation as well to see if this further enhances the training benefits observed here. Lastly, tracking correlations of SRL

changes with future academic performance is important to see how well these gains work in the real world.

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Appendix

Appendix A: Examples from declarative knowledge test

Example Question 1: When a student perceives him or herself to be participating in a task for reasons such as challenge, curiosity, mastery this is known as:

1. Extrinsic motivation
2. Intrinsic motivation
3. Task value
4. Mastery self-efficacy

Example Question 2: Which of the following is an example of a metacognitive strategy:

1. Matt makes sure he keep up with the weekly readings and assignments in his course.
2. Matt works hard to do well in his class even if he doesn't like what they are doing.
3. Matt tries to think through a topic and decide what he is supposed to learn from it rather than just reading it over when studying.
4. Matt tries to play around with ideas of his own related to what he is learning in his course.

Example Question 3: The first step self-regulated learners typically do when faced with a learning task is

1. They begin by analysing the task, establishing goals, interpreting task requirements in terms of their current knowledge and beliefs *and working out strategic plans to reach your goals*
2. They monitor their progress toward goals, thereby generating internal feedback about the success of their efforts
3. They set task-specific goals, which they use as a basis for selecting, adapting, and possibly inventing strategies that will help them accomplish their objectives
4. They use motivational strategies to keep themselves on task when they become discouraged or encounter difficulties

Appendix 2: Example questions from mobile-app based diary**Example question BEFORE/AFTER study session about affect:**

How do you feel at the moment?

- a) **Active:** 1-very slightly or not at all, 2-a little, 3-moderately, 4-quite a bit, 5-extremely.
- b) **Determined:** 1-very slightly or not at all, 2-a little, 3-moderately, 4-quite a bit, 5-extremely.
- c) **Distressed:** 1-very slightly or not at all, 2-a little, 3-moderately, 4-quite a bit, 5-extremely.
- d) **Nervous:** 1-very slightly or not at all, 2-a little, 3-moderately, 4-quite a bit, 5-extremely.

Example question BEFORE study session about motivation

Today, I am studying because I find the topic very interesting: strongly disagree, disagree, neutral, agree, strongly agree.

Example question BEFORE study session about learning strategies

Today, I have made a time schedule: strongly disagree, disagree, neutral, agree, strongly agree.

Example question AFTER study session about motivation

Today, I said to myself: I am able to do it: strongly disagree, disagree, neutral, agree, strongly agree.

Example question AFTER study session about learning strategies

Today, I put much effort into my work: strongly disagree, disagree, neutral, agree, strongly agree.

Appendix 3: Structure of the online SRL training program

Session	Topics	Content and activities
Training Session 1	Self-regulated Learning	<ul style="list-style-type: none"> • SRL overview. • Components of SRL. • Three Phases of SRL.
	Goal Setting and Barriers	<ul style="list-style-type: none"> • What is your long-term goal, midterm goal, SMART goal. • BEST barriers. • Barriers and Strategies.
	Time Management	<ul style="list-style-type: none"> • Overview. • Skills and planning. • Time Management style self-assessment quiz. • Time management planner.
Training Session 2	Distractions and Procrastination	<ul style="list-style-type: none"> • Overview. • Distraction Apps. • Reflect and identify distractors.
	Learning Strategies	<ul style="list-style-type: none"> • Critical Thinking. • Organisation. • Elaboration. • Mnemonics. • Mind Palace. • Paraphrasing. • Note Making. • Comparisons • Self-Questioning. • Resource Management. • Peer Learning • Help Seeking. • Metacognitive Strategies.
Training Session 3	Dealing with Failure	<ul style="list-style-type: none"> • Attribution theory. • Self-Serving Bias. • Fundamental attribution error. • Frame of reference.
	Motivation	<ul style="list-style-type: none"> • Intrinsic vs Extrinsic Motivation. • Strategies to increase motivation.
	Self-Efficacy	<ul style="list-style-type: none"> • What is self-efficacy. • Ways to develop self-efficacy beliefs.
	Self-Reflection	<ul style="list-style-type: none"> • Reflection • Revision of SRL

Note. SRL = self-regulated learning, SMART = specific, measurable, attainable, realistic and timely. BEST = behaviour, emotion, situation, thoughts.

Appendix 4: Examples from online SRL training program

Below are a few examples from the training sessions. The training was split into sessions and then designed as mini-chapters within a session. Chapters contained micro-learnings in the form of written and video content, activities, reflective tasks and quizzes.

Example: structure of sessions session

- Welcome to Session 1
- Chapter 1 – The Self-regulated learning process model
- Chapter 2 – Goal Setting and Barriers
- Chapter 3 – Time Management
- Questions after each training session

Example content: S.M.A.R.T goals

Goal setting

Many students begin university life with hopes of doing well and succeeding in their studies. However, the transition to university life is often filled with lots of new commitments and exciting new interests, and lots of students begin to feel unmotivated as their dreams of doing well at university seem to slip further away.

Setting, writing, and tracking goals can be one of the most powerful tools to set you back on track towards achieving success in your learning experiences. But to write great goals, we must be S.M.A.R.T!

SMART goals are Specific, Measurable, Attainable, Realistic/Relevant, and Time-bound.

- Specific goals identify what is to be done and why, and state the outcome or expected result.
- Measurable goals are stated in terms that are observable or verifiable.
- Attainable goals are those that are not beyond your reach.
- Realistic goals should be challenging, but not impossible to reach. Or Relevant – does it fit in with other goals?
- Time-based goals described within the context of a specified time frame and may include sub-goal.

Example: Video

Resource management strategies: peer learning and help-seeking

“Recognising when you need help and how to get help is an important step in reaching your academic goal”

One particular characteristic of a successful self-regulated learner is their ability to know how and when to seek out help from others when they encounter ambiguities and difficulties in the learning process.

It is completely okay to sometimes feel lost when learning new content, which can be made all the more difficult if challenging life events are piled on top. When this happens, students who are considered to have a self-regulated learning approach use their skills and metacognitive abilities to isolate, direct, monitor and adjust their performance. While it is a good start to know when to seek help, self-regulated learners also tend to go that extra step in motivating themselves to actively seek help when they need it, whether it is asking peers to discuss a key idea, or asking the teacher to go over a tricky concept once more. This helps to ensure that learning can continue to progress because by seeking help, self-regulated learners are ensuring they acquire the important skills and strategies that will allow them to become more independent learners in the future.

These help-seeking steps and processes are evidence that self-regulated learners are actively engaged in their own learning process, and they demonstrate awareness of their own thinking (i.e., metacognition).

Example: Activity

In a crowded classroom, it can be tough to identify which students are challenging themselves, and which are really struggling. Explore different types of help-seeking and help-giving behaviors below:

Reporting & Analysis: Sarah E. Smith, Illustration: Vanessa Solt, Design: Pongkorn, Education Week

Here are some handy places to seek help with your studies:

- Class or study subject Facebook groups:** Fantastic way to seek peer support and keep connected with your classmates.
- Asking questions in class:** you will be able to test your knowledge in real-time and seek clarification as the need arises. Remember, if your classmates will also have the same question! Don't be afraid to ask!
- Your teacher:** your primary support during your studies, and is there to provide you with expert knowledge on the topic. He/she is the learning process, and seeking their help when needed is a strong indicator of becoming a self-regulated learner. This also applies to off-campus or part-time.
- University provides you with many valuable online resources,** including informative videos on how to develop effective time-to-face essay writing support, how to search databases, where to find student services, and how to plan for your studies. These are all off-campus or part-time.
- University librarians** are often one of the most knowledgeable and useful people to know! With years of training and experience in a wonderful people provide an invaluable wealth of skills training and support for university students. You can choose to email, attend the workshops and seminars they often organise to help students study more effectively.

Each of these students is demonstrating good help-seeking behavior:

Example content: help-seeking and peer-learning