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Self-regulated learning support in flipped learning videos enhances learning outcomes

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ABSTRACT

In flipped learning, students study learning material before class and apply the content of the learning material during class. This requires self-regulated learning (SRL) behavior due to the increased autonomy in this instructional approach. Providing students with video-embedded SRL support (i.e., prompts and explicit instruction) during the learning activities before class has proven to be an effective strategy in primary and higher education to enhance students' SRL and learning outcomes. The current study aims to replicate the effects of SRL support in a Flipped class in secondary education over the course of eight weeks. In total, 115 eighth-grade students from five classes participated in a quasi-experimental study, which measured the effects of SRL support on students' SRL (self-reports and online activities), learning outcomes, and satisfaction. We found a positive effect of SRL support on learning outcomes, but we could not explain this by differences in students' SRL. Although all the students were generally positive about the flipped learning environment, some students clearly disliked the SRL instruction. We conclude that SRL support is beneficial for students' learning but that it should be carefully designed to avoid students' dissatisfaction, which could potentially nullify these beneficial effects on learning.

1. Introduction

Flipped learning (FL) is an effective approach to increasing students' learning outcomes, in which they study learning material before class (e.g., by watching instructional videos) and apply the content of the learning material during class (van Alten, Phielix, Janssen, & Kester, 2019; Cheng, Ritzhaupt, & Antonenko, 2019; Låg & Sæle, 2019). To benefit from FL, self-regulated learning (SRL) behavior (e.g., monitoring) is required (He, Holton, Farkas, & Warschauer, 2016; Shih & Huang, 2019). However, students do not always use optimal learning strategies during self-study (Dirkx, Camp, Kester, & Kirschner, 2019), and can even resist changing their study behavior during FL (Boevé et al., 2017). Providing students with SRL support (e.g., by prompts) during their learning activities before class has proven to be an effective strategy for enhancing students' SRL and learning outcomes during short-term FL interventions (e.g., one session or a few weeks) in primary education (Lai & Hwang, 2016) and higher education (Moos & Bonde, 2016). The current study investigates the effects of SRL support during FL in secondary education over the course of eight weeks.

1.1. Higher demand on SRL skills in FL

Students that show SRL behavior actively regulate and monitor their cognition, behavior, and motivation while learning, and this

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involves strategies and goal processes (Panadero, 2017; Zimmerman and Moylan, 2009). Self-regulated learners have the ability and motivation to think about how, what and why they are learning (i.e., metacognition) and thereby control their learning behavior (i.e., self-regulation). Self-regulated learning has been theorized as a cyclical model in which SRL occurs consecutively in a forethought phase (e.g., task analysis), a performance phase (e.g., self-control and monitoring), and a self-reflection phase (e.g., self-judgment and change behavior accordingly) while learning (Zimm erman & Moylan, 2009).

In the case of FL, which is an example of a blended teaching strategy, students are given more autonomy over their learning process. This puts a higher demand on students' SRL skills (He et al., 2016; Lee & Tsai, 2011; Shih & Huang, 2019; Tan, Yue, & Fu, 2017). The extent to which students are given autonomy differs according to the implementation of FL (Van Laer & Elen, 2017). First, students can perceive different levels of autonomy, depending on how much control they are given over studying various learning material (Bouwmeester et al., 2019; Shih & Huang, 2019). Second, students' autonomy is also affected by the degree to which students can manipulate the pace and sequencing (e.g., by pausing and rewinding the instructional videos) of the learning content (Abeysekera & Dawson, 2015; Van Laer & Elen, 2017), and also by their decisions as to where (environmental structuring) and when (planning) to learn (Jansen, van Leeuwen, Janssen, & Kester, 2018). Consequently, when students are able to regulate their own learning adequately and according to their increased autonomy, they achieve higher learning outcomes during FL in comparison with students who are not able to do so (Lai & Hwang, 2016; Lee & Choi, 2019; Shibukawa & Taguchi, 2019).

However, this high level of autonomy and the consequent demand on students' SRL skills in FL could pose problems for students (Butzler, 2016; Heyma et al., 2015; Lee, Lim, & Grabowski, 2010; Sletten, 2015; Wolters, Pintrich, & Karabenick, 2005). Even if students understand that different study behavior is necessary to benefit from FL, they do not always change their learning behavior, and they may even resist doing so (Boevé et al., 2017). In addition, research shows that students' knowledge about cognitive learning strategies is lacking, which in turn hampers metacognition during self-study, as students do not always use optimal learning strategies (Blasiman, Dunlosky, & Rawson, 2017; Dirkx et al., 2019). On the one hand, this could be explained by the lack of sufficient training in effective study strategies such as distributed practice and retrieval practice (Dignath & Büttner, 2018; Surma, Vanhoyweghen, Camp, & Kirschner, 2018). On the other hand, this could be explained by age, as younger students have fewer SRL skills (Dent & Koenka, 2016; Wigfield, Klauda, & Cambria, 2011). This could be a challenge for students applying FL, as they could lack sufficient metacognitive skills and cognitive learning strategies to fully benefit from the increased autonomy (e.g., Heyma et al., 2015).

1.2. SRL support in online FL environments

As students may struggle to apply SRL to fully benefit from FL, supporting students' SRL in an FL environment seems worthwhile. Previous research has shown that supporting SRL by means of SRL interventions (e.g., SRL instruction and SRL prompts) enhances students' SRL and in turn (at least partly) enhances learning outcomes (Dent & Koenka, 2016; Dignath & Büttner, 2008; Donker, de Boer, Kostons, Dignath van Ewijk, & van der Werf, 2014; Jansen, van Leeuwen, Janssen, Jak, & Kester, 2019; Zheng, 2016). In general, in the context of blended learning, Van Laer and Elen (2017) found seven key attributes that can support SRL: authenticity, personalization, learner-control, scaffolding, interaction, cues for reflection, and cues for calibration. The cues for reflection (defined as SRL prompts) are known to be effective in supporting students' SRL (Devolder, van Braak, & Tondeur, 2012) and have also been studied in the particular context of FL. For example, SRL prompts are given to students learning from instructional videos, in the form of encouragement and questions (e.g., 'Explain what you have learned' and 'What have you learned?') to motivate them to engage in SRL activities.

The theory behind the effectiveness of SRL support is that students are informed about and encouraged to engage in SRL activities in each phase of learning: to set goals and plan in the forethought phase, to monitor and control their learning in the performance phase, and to evaluate their own learning and set goals in the self-reflection phase (Moos & Bonde, 2016; Zimmerman and Moylan, 2009). A substantial number of studies have concluded that providing students with this form of SRL support during online learning activities before class leads to higher SRL (measured through self-reports or online activities) and learning outcomes (Butzler, 2016; Jovanović, Gašević, Dawson, Pardo, & Mirriahi, 2017; Jovanovic, Mirriahi, Gašević, Dawson, & Pardo, 2019; Lai & Hwang, 2016; Moos & Bonde, 2016; Shyr & Chen, 2018; Sletten, 2017; Sun, Xie, & Anderman, 2018; Yılmaz, Olpak, & Yılmaz, 2018). In addition, we know from research that SRL support should be embedded in the learning environment to stimulate students' optimal use of the support (Clarebout, Horz, Schnotz, & Elen, 2010) and is best implemented in a context-specific manner and not as an independent form of instruction (e.g., Paris & Paris, 2001).

Nevertheless, there are still knowledge gaps in the scientific literature that we address in the current study. First, previous research into SRL support in FL focused specifically on (video-embedded) SRL prompts (Devolder et al., 2012). Prompting SRL has proven to be effective in enhancing learning outcomes in primary education (Lai and Hwang, 2016) and higher education (Moos and Bonde, 2016) The theoretical novelty in the current study is that we added explicit SRL instruction to this type of intervention to investigate whether it improves SRL support in secondary education. Previous research into improving students' SRL skills in other online learning contexts has supported the idea that adding explicit instruction of SRL in an online learning environment could be a beneficial teaching strategy for enhancing students' SRL and learning outcomes (Bannert, Hildebrand, & Mengelkamp, 2009; Jansen, van Leeuwen, Janssen, Conijn, & Kester, 2020; Kistner et al., 2010; Kramarski, Weiss, & Sharon, 2013; Moos & Ringdal, 2012; Paris & Paris, 2001). Therefore, the current study combines two effective SRL support strategies: not only prompting students *when* SRL behavior is beneficial, but also demonstrating *how* they could do it, and *why* it is important.

Second, there is a lack of data regarding the effectivity of SRL support in ecologically valid FL settings (i.e., over the course of multiple weeks in a real classroom, rather than in a laboratory setting), and in particular in secondary education (Greene et al., 2015). In contrast to previous research in higher education, one of the first SRL prompt interventions within secondary education found no

differences in terms of learning outcomes between students who received SRL prompts and students who did not (van Alten, Phielix, Janssen, & Kester, 2020). In addition, previous research has shown the importance of SRL support for the SRL development of primary and secondary education students (Dignath & Büttner, 2008; Muijs & Bokhove, 2020; Veenman, Van Hout-Wolters, & Afflerbach, 2006; Wigfield et al., 2011). Therefore, more research is necessary to determine whether what we know from research in the context of higher education is applicable to secondary education.

Third, previous research showed that students with high prior knowledge of a certain topic perform more online SRL activities than students with low prior knowledge (Moos & Azevedo, 2009; Taub, Azevedo, Bouchet, & Khosravifar, 2014). It could be possible that the effect of SRL support on SRL is dependent on students' prior knowledge (Kramarski et al., 2013; Lim, Lee, & Grabowski, 2009; Sergis, Sampson, & Pelliccione, 2018; Yeh, Chen, Hung, & Hwang, 2010). For example, students with low prior knowledge could find benefiting from SRL support difficult as it is cognitively demanding (Schwonke et al., 2013). In contrast, students with low prior knowledge have been found to benefit more from SRL support, for example because they are more dependent on guidance in effective learning strategies and resource management in comparison with students with high prior knowledge who are better able to assess the effectiveness of their own learning (Schwonke et al., 2013). The moderating role of prior knowledge has not yet been investigated in SRL support research in FL.

Fourth, little research has been carried out to investigate the relationship between students' SRl activity and students' satisfaction. Research has shown that students struggle with effectively applying SRL during self-study (e.g., Blasiman et al., 2017; Dirkx et al., 2019). This can be related, for example, to their views on FL (Boevé et al., 2017), or to their appreciation of the SRL support (van Alten et al., 2020). In general, students' satisfaction about the learning environment is an important condition for students to perform and develop SRL in higher education (Shih, Liang, & Tsai, 2018) and secondary education (Schuitema, Peetsma, & van der Veen, 2012). Hence, if students are not satisfied with the FL environment, it could hinder their participation and their use of the SRL support. Therefore, it is relevant to investigate students' satisfaction with the online learning environment and about the SRL support in addition to the effects of the SRL prompts, in order to better explain the effect of SRL support on students' learning.

1.3. Present study

Consequently, we answer the following research questions (RQs) in the present study: What is the effect of SRL support during FL on secondary education students' SRL self-reports (RQ1a) and online SRL activity (RQ1b)? What is the effect of SRL support during FL on learning outcomes of secondary education students (RQ2)? For these first two research questions, we hypothesize that students who are regularly supported in performing SRL activities during their learning process, and who are provided with instruction about how to do it and why it is important (SRL-support condition), outperform students without SRL support (no-SRL-support condition).

In addition, we investigate if students' prior knowledge moderates the effects of SRL support (RQ3). An interaction between prior knowledge and the research conditions on SRL or learning outcomes, would indicate that SRL support works better for students with a higher (or lower) prior knowledge.

Finally, we answer two questions regarding student satisfaction: what is the effect of SRL support during FL on secondary education students' satisfaction about the online learning environment (RQ4a) and how do students in the SRL support condition value the SRL support (RQ4b)?

2. Method

2.1. Design

We used a between-subjects design with SRL support (instruction and prompts) in the instructional videos for the intervention condition, and no SRL support in videos for the control condition. The intervention consisted of 10 lessons (and eight videos) over the course of eight weeks. In this quasi-experimental design, three teachers each taught two different pre-existing classes. For each teacher, we randomly allocated one of their classrooms to the intervention condition and the other to the control condition to balance the impact of teacher effects in our design.

2.2. Participants

A total of 156 eighth-grade students in their second year of Dutch secondary education (13–14 years old) and their parents were asked for their consent to participate in this study. Ethical approval was obtained from the Faculty Ethics Review Board. All students were compensated with a small gift after the intervention, and participants had a chance of winning one of six vouchers (10 euros each) that were raffled in each class after the intervention.

The study took place in a large urban school (2200 students) and the intervention was part of the students' regular school curriculum in 2019 from May to July. The Netherlands has a tracked secondary education system (from Grade 7 onwards), and the school offers the two highest tracks: *senior general* and *pre-university*. *Pre-university* consists of both *atheneum* and *gymnasium* levels the latter including Latin and Greek as compulsory courses. The sample consisted of six pre-existing classes and three teachers, including the first author, who each taught two classes.

After *a priori* equivalent tests, it appeared that there were significant ($p < .05$) differences between conditions in terms of prior knowledge, self-reported SRL skills and motivation. These differences were due to the inclusion of different educational levels and an unequal distribution across conditions: *senior general* level ($n = 22$), *atheneum* level ($n = 119$), and *gymnasium* level ($n = 10$). Therefore,

we excluded the students from the *senior general* and *gymnasium* levels to minimize *a priori* differences between conditions and enable a fair comparison. Thus, the participants of the current intervention were representative of approximately 20% of Dutch secondary education students following the *pre-university* track.

In addition, five students were excluded because consent was not obtained. Finally, we excluded four students due to non-compliance, as they did not watch at least 70% of the instructional videos. For the students in the SRL support condition, non-compliance indicated that they were not sufficiently exposed to our intervention (Jo, 2002). The four excluded students were allocated to the SRL-support condition. Consequently, our sample consisted of 115 students (50 in the SRL-support condition and 65 in the no-SRL-support condition) from five classes. *A priori* power analyses indicated that a sample size of 152 students was required for sufficient power of 80% and for detecting medium effect sizes as expected by previous research. The current included sample provides a power of 50–60% to detect medium effect sizes.

2.3. Materials

2.3.1. Learing materials

Edpuzzle (https://edpuzzle.com/) was used as an online learning environment for sharing the instructional videos with the students. We provided each student with a personal login that was linked to their corresponding research condition. The videos were developed and recorded by the first author. The eight videos were identical for both research conditions, they had an average length of 7 min, and fast forwarding was disabled when watching the video for the first time.

The learning materials used for the in-class lessons were integrated into the school's regular History curriculum (the Industrial Revolution during the late 19th and early 20th centuries) and were developed in collaboration with participating teachers, using teaching materials that were already used in the participating school. Every student was provided with a workbook, which included instructions about Edpuzzle, lesson procedures, and three corresponding cognitive questions (in both conditions) corresponding to each instructional video (e.g., 'What are advantages of building steam factories in the city?'). Teachers discussed the cognitive questions at the start of each lesson to recall the content of the instructional videos. During the lessons, students were actively engaged in applying the content of the instructional videos (e.g., analyzing historical sources and creating advertisement leaflets to explain the benefits of 19th century industrial inventions).

2.3.2. SRL support

The difference between the SRL-support condition and the no-SRL-support condition was twofold. A detailed overview of all the SRL support (prompts and instruction) for each video is presented in Table A.1. First, the students in the SRL-support condition received three to four SRL prompts per video, corresponding to the three SRL phases (forethought, performance, and self-reflection; Zimmerman and Moylan, 2009). The SRL prompts in this research were based on the study of Moos and Bonde (2016) and focused on every aspect of SRL (e.g., planning, help seeking, metacognitive activities, and time management). Students were required to think about the SRL prompts and answer them to continue the video.

Second, a brief SRL instruction was added at the beginning or at the end of the video. We presented the SRL instruction to students with a gradual reduction in content (i.e., fading or scaffolding) with the aim that students would internalize the SRL strategies instructed (Kollar & Fischer, 2006). The SRL instruction focused mainly on providing students with explicit reasons for thinking about their own learning and why this is useful. We also provided them with proper metacognitive strategies (e.g., time management, environmental structuring, help seeking, and monitoring understanding) and cognitive learning strategies (e.g., spaced practice and how to make notes). Most SRL prompts were built upon the SRL instruction at the beginning of the video (see Table A.1). Monitoring prompts sometimes referred to the quiz questions in the workbooks, followed up by explicit instruction about why this is an effective monitoring strategy.

2.4. Measurements

2.4.1. SRL log data

Edpuzzle was used to collect SRL log data. We used the following three variables as indications of SRL activity: students' *video timing*, *video completion rate*, and *rewind actions* (cf. Bannert, Reimann, & Sonnenberg, 2014; Maldonado-Mahauad, Pérez-Sanagustín, Kizilcec, Morales, & Munoz-Gama, 2018). For *video timing*, log data included whether a student completed the instructional video on time (2), too late (i.e., after the deadline, which was the beginning of class; 1), or did not complete (0). We calculated the mean video timing score of all the videos. For *video completion rate*, we calculated the percentage of the video completion rate of each individual student (e.g., on a score from 0 to 100%). *Video timing* and *completion rate* can be considered to be SRL activities in the forethought phase (e.g., planning) and performance phase (e.g., time management, persistence), respectively, according to the SRL model by (Zimmerman and Moylan (2009)). For *rewind actions*, we counted all rewind actions (i.e., when students watched a portion of a video more than once) and calculated a sum score. Every video was automatically divided into 10 portions, and log data were available about how often a student watched a particular portion. *Rewind actions* is an indication of SRL activity in the performance and self-reflection phases, in which students monitor and evaluate their understanding of the learning content and consciously choose to repeat a part of the instruction.

In addition, the first author coded how many valid (e.g., serious) online answers to the SRL prompts were given by students in the SRL-support condition. The resulting average per video is an indication of *SRL prompt compliance* which we used to evaluate to what extent the students in the SRL-support condition properly worked with the prompts.

2.4.2. SRL questionnaire

The revised self-regulated online learning questionnaire (SOL-Q-R) was used to measure students' SRL self-reports (Jansen et al., 2018). This questionnaire contains the following seven scales for which we calculated scale means: *metacognitive activities before*, *during*, and *after* learning, *time management*, *environmental structuring*, *persistence*, and *help seeking*. We translated and contextualized the SOL-Q-R, originally constructed for online learning, to the Dutch student population of 14–15 years (e.g., '*I think about what I have learned after I finish working on* homework *for History*') and deleted one to two items in each scale to reduce the duration and avoid students providing non-serious answers. As can be seen in Table B.1, the reliability of the scales in general was acceptable. However, due to the low Cronbach's α for *environmental structuring* (0.36), we dropped this scale from further analysis.

2.4.3. Motivation questionnaire

Motivation was measured only as a pre-test, to investigate if the students in the research conditions were equal in terms of motivation. We used the Motivated Strategies for Learning Questionnaire (MSLQ) and calculated scale means (Pintrich, Smith, Garcia, & McKeachie, 1991). The MSLQ is the most widely used questionnaire that has proven to be a reliable and useful tool for measuring motivational and SRL constructs (Duncan & Mckeachie, 2005). We used the following motivational constructs, as they cover all aspects relevant to SRL. *Intrinsic goal orientation*, *extrinsic goal orientation*, and *task value* were used to measure how students valued and perceived their engagement in a particular learning task (e.g., homework for History). *Self-efficacy for learning* was included to measure students' expectancy beliefs about how they complete their History homework. As can be seen in Table B.2, the scales for our translated and contextualized version were reliable.

2.4.4. Prior-knowledge test

We developed a prior-knowledge test about the content of the lessons (i.e., the Industrial Revolution). We used the test to detect possible differences between research conditions before the intervention. In addition, we aimed to answer RQ3 to determine whether prior knowledge moderates the effects of SRL support on SRL and learning outcomes. The test was presented to students as a quiz on paper and completed during class before the intervention started. It contained seven multiple-choice questions and two open questions about a historical source. The first author scored all the tests. We calculated a sum score for the prior-knowledge test. The reliability of the test was low in terms of Cronbach's α (9 items; $\alpha = 0.26$), but this is an expected value when using (pre)knowledge tests that usually do not measure the same underlying construct (Taber, 2018).

2.4.5. History performance level

The intervention took place at the end of the school year. To further assess *a priori* differences between the research conditions, we therefore used *history performance level* as an additional measure that indicated a student's performance for this subject in that particular year. We calculated a mean score for all the students' test scores for History in the current schoolyear. This score is commonly used by schools to evaluate whether a student meets the criteria to pass to the next grade.

2.4.6. Learning outcome test

The learning outcome test was developed by the researchers and participating teachers and was based on learning materials and was comparable to tests which students usually complete during the schoolyear. Every participating student received the same test in class during a regular test week at the end of the school year. The test consisted of 24 items, of which four were multiple-choice questions. The 20 open questions contained recall (e.g., give the definition of a concept), comprehension (e.g., explain the impact of a concept), and transfer (e.g. relate a historical source to a concept) assignments. Each teacher made use of a comprehensive assessment scheme (validated by the researchers and teachers) to score the tests of their own students. The inter-rater reliability of the open-question scores was assessed by the first author, who independently scored a random sample of five unscored tests from the other classes and compared these with the other teachers' scores (20 tests and 400 items in total). We deleted one item for which Cohen's κ was too low ($\kappa = 0.30$, 60% agreement rate). The Cohen's κ values for the remaining items were substantial with an average Cohen's κ of 0.80 (SD = 0.14, range $\kappa = 0.53$ to 1, $p < .001$) and an average total agreement of 85%. In general, the remaining items (open and closed questions) together were found to be reliable (24 items; $\alpha = 0.83$), and we calculated a sum score as an indication of students' learning outcomes.

2.4.7. Student satisfaction

To measure student satisfaction with the learning environment (i.e., the online videos), we added six Likert-items (range from 1 to 7; e.g., '*I think the instructional videos are boring*'; '*I think the instructional videos are instructive*'; '*I believe that the instructional videos are designed in a clear and understandable way*') to the post-test questionnaire to create a mean score. In general, the *satisfaction* questionnaire was found to be reliable ($\alpha = 0.85$). In addition, we performed a confirmatory factor analysis in Mplus (version 8) to verify the underlying one-factor structure. As shown in Table B.3, all goodness-of-fit indicators showed an acceptable model fit (Kline, 2005; Kyriazos, 2018). In addition, students in the SRL-support condition received four additional Likert-items about their experience with the SRL support which we used to describe their general satisfaction about the design of the SRL support (e.g., '*The learning tips I received at the beginning/end of the videos were useful to learn better*'; '*The questions that were part of the videos annoyed me*').

Finally, we added several evaluative questions to the post-test questionnaire to better interpret students' behavior in our FL experiment. First, we asked all students two open-answer questions about the general benefits of or points of improvements for FL. Second, we provided students with four statements with possible reasons why they watched the videos and five statements why they did not watch the videos. Students were free to select unlimited motives for (not) watching the videos.

2.5. Procedure

Before the flipped intervention started, the students separately completed the pre-test questionnaire, with the SRL and motivation items, and the prior-knowledge test during regular class time. Students were briefed about working in an FL class and the procedures which they were expected to meet. In addition, students received classroom instruction on how to access the videos at home. They were also informed that their own teacher could track their progress. To stimulate students to comply with the instructions and complete their homework, we informed students that watching the videos in time would be rewarded with a bonus point (which was not included in our analysis) in their final test score.

Teachers were told not to change their usual teaching interaction with their students, and received instructions and training on how to apply the learning materials for each lesson. The teachers used the school's digital homework system to inform students of their own class about the required preparations for each lesson (one instructional video and the accompanying quiz questions about the learning content in their workbooks). Each lesson of 65 min started with retrieval practice activities about the content of the videos and a discussion of the quiz questions from the workbooks. This was usually followed by a complementary micro-lecture of approximately 10 min to discuss parts that were not yet fully understood as well as more in-depth aspects of the learning material. The remaining part of the lesson was dedicated to engaging learning activities to apply the learning material (e.g., creating advertisement posters, writing essays, analyzing historical sources). After 10 lessons, students completed the posttest SRL and satisfaction questionnaire during regular class time. In the subsequent test week, students had 65 min to complete the learning outcome test.

2.6. Data analysis

We first checked the data distribution for normality and potential outliers. In the event that dependent variables were not normally distributed (e.g., *completion rate*), we performed a bootstrapping method (2000 Bootstrap samplings) with replacement to estimate the impact of non-normality (Adèr, Mellenbergh, & Hand, 2008; Field & Wilcox, 2017). In case of an *a priori* difference between the research conditions for one of the pre-test variables (i.e., *task value*), we included the respective variable as covariate in the models (Steiner, Wroblewski, & Cook, 2009).

Next, we analyzed the differences between the SRL-support and the no-SRL-support conditions for the variables of each research question. Due to the linear relationships between the dependent variables (see Table B.4), we decided not to conduct one MANCOVA. Instead, we performed two separate MANCOVAs (with the SRL self-report scales and the SRL activity variables as dependent variables respectively), and two ANCOVAs (i.e., learning outcome test and satisfaction as dependent variables respectively) in SPSS with condition as independent variable and *task value* as a covariate.

To examine if prior knowledge moderated the findings, we added students' prior knowledge as a covariate to the existing models and checked for a possible interaction effect between performance level and condition, which would suggest that the SRL support had a differential effect according to students' prior knowledge. To answer the final research question about the students' satisfaction with the learning environment, we analyzed students' mean scores on the relevant post-test questions.

3. Results

3.1. Evaluation of a priori differences between conditions

As part of the quasi-experimental protocol, we checked for *a priori* differences between the students in the SRL-support and no-SRL-support conditions *before* the intervention. In Table B.5, we present the descriptive statistics for all the pre-test dependent variables for both research conditions.

We conducted three separate MANOVAs, in which we included condition as a factor and the related pre-test measures (i.e., SRL self-reports, motivation, and cognitive abilities) as dependent variables. We found no significant difference between conditions in a MANOVA including the six SRL self-reported pre-test scales, $F(6, 108) = 0.74$, $p = .619$; Wilk's $\Lambda = 0.961$.

For students' motivation, we found a significant difference between conditions in a MANOVA with the four motivation scales, $F(4, 110) = 2.84$, $p = .028$; Wilk's $\Lambda = 0.906$. Follow-up ANOVAs showed that, for the motivation scale *task value* ($p = .009$, partial $\eta^2 = 0.06$), the students in the SRL-support condition scored significantly higher ($M = 4.27$, $SD = 1.52$, $n = 50$) than those in the no-SRL-support condition ($M = 3.53$, $SD = 1.44$, $n = 65$), but not for the other three motivation scales.

With regard to student's cognitive abilities, we found no significant differences between conditions in a MANOVA including *prior knowledge* and *history performance level* as dependent variables and condition as a factor, $F(2, 104) = 1.10$, $p = .337$; Wilk's $\Lambda = 0.979$.

Overall, there were no *a priori* differences between students from both research conditions except for *task value*. In the following results, we included *task value* in each subsequent analysis as a covariate (Steiner et al., 2009). Correlations between *task value* and most of the dependent variables were $r > 0.36$, $p < .001$.

3.2. Effects of SRL support

In Table 1, we present the descriptive statistics for all the dependent variables of both research conditions. We also assessed *SRL prompt compliance* to estimate how effectively students in the SRL-support condition have worked with our SRL intervention. The average of valid (i.e., serious) student answers per video was 86% and ranged from 79% (video 4) to 93% (video 2). We concluded that, in general, students worked properly with the SRL prompts.

Table 1
Mean and Standard Deviation for the Dependent Variables per Condition and *P*-values of the Analyses.

Dependent variables (post-test)	SRL-support condition			No-SRL-support condition		
	n	M	SD	n	M	SD
SRL self-report scales ($p = .555$)						
Metacognitive activities before	50	3.25	1.17	65	3.21	1.00
Metacognitive activities during	50	3.95	1.01	65	3.68	1.01
Metacognitive activities after	50	3.16	1.30	65	3.04	1.18
Persistence	50	4.82	1.05	65	4.55	1.28
Help seeking	50	4.29	1.30	65	4.34	1.13
Time management	50	4.56	1.14	65	4.55	1.04
SRL online activity ($p = .214$)						
Video completion rate	50	97.38	6.45	65	99.04	4.01
Rewind actions	50	48.40	47.17	65	42.32	48.95
Video timing	50	1.85	0.25	65	1.93	0.14
Learning outcomes ($p = .025$)						
Learning outcome test	50	20.47	4.92	65	17.65	5.98
Satisfaction ($p = .184$)						
Satisfaction with learning environment	50	5.39	0.88	65	5.41	1.26

Note: Provided *p*-values are from the separate (M)ANCOVAs.

3.2.1. SRL self-reports

To assess whether SRL support enhances self-reported SRL (RQ1a), we performed a MANCOVA with condition (SRL-support versus no-SRL-support) as a factor and the six SRL self-report scales as dependent variables. We found no significant main effect of condition on SRL self-reports, $F(6, 107) = 0.82$, $p = .555$; Wilk's $\Lambda = 0.956$, partial $\eta^2 = 0.04$.

3.2.2. SRL online activity

To assess whether SRL support increases online SRL activity (RQ1b), we performed a MANCOVA with condition as a factor, *completion rate*, *rewind actions*, and *video timing* as dependent variables. We found no significant main effect of condition on SRL online activities, $F(3, 110) = 1.52$, $p = .214$; Wilk's $\Lambda = 0.960$, partial $\eta^2 = 0.04$.

3.2.3. Learning outcomes

To evaluate whether SRL support increases learning outcomes (RQ2), we performed an ANCOVA with condition as factor and the learning outcome test score as the dependent variable. We found a significant main effect of condition on learning outcome, $F(1, 111) = 5.13$, $p = .025$, partial $\eta^2 = 0.04$. As can be seen in Table 1, students in the SRL-support condition scored higher than those who did not receive SRL support.

3.2.4. Prior knowledge as possible moderator

To assess whether students' prior knowledge moderated the effects of SRL support (RQ3), we performed two separate MANCOVAs and one ANCOVA. We added prior knowledge as a covariate, condition as a factor, and the SRL questionnaire scales, the SRL online activity variables, and the learning outcome test as dependent variables to the separate models.

We found no significant interaction effects between prior knowledge and condition on the SRL self-reports, $F(6, 97) = 1.17$, $p = .331$; Wilk's $\Lambda = 0.933$, partial $\eta^2 = 0.07$; no significant interaction effects between prior knowledge and condition were found for the SRL online activities, $F(3, 100) = 9.89$, $p = .402$; Wilk's $\Lambda = 0.971$, partial $\eta^2 = 0.03$; and no significant interaction effects between performance level and condition were found for learning outcomes; $F(1, 101) = 0.02$, $p = .892$, partial $\eta^2 = < 0.01$. Overall, the effects of SRL support on SRL (self-reported and online activity) and learning outcomes did not depend on the level of students' prior knowledge.

3.2.5. Satisfaction

First, we examined whether students who received SRL support valued the instructional videos differently than students who did not receive SRL support (RQ4a). We performed an ANCOVA with condition as factor and the satisfaction score as a dependent variable. We found no significant main effect of conditions on satisfaction, $F(1, 110) = 1.79$, $p = .184$, partial $\eta^2 = 0.02$.

Second, we evaluated how students in the SRL-support condition valued the SRL support in the videos (RQ4b). We provide

Table 2
Mean and Standard Deviation for Satisfaction about the SRL support on a Scale from 1 to 7 (1 = totally disagree and 7 = totally agree).

Question	*n*	*M*	*SD*
The questions that were part of the videos were useful to learn better	49	4.37	1.91
The questions that were part of the videos annoyed me	48	4.42	1.97
The learning tips I received at the beginning/end of the videos were useful to learn better	49	2.31	1.48
The learning tips I received at the beginning/end of the videos annoyed me	48	5.17	2.01

Table 3
Results What Students Valued about the FL Method and What Could be Improved, $n = 115$ Students.

(1) What did you like about the FL method?	*n*	(2) Do you have any points of improvements for the FL method?	*n*
I learned better	36	Negative comment about the SRL instruction (e.g., distracting, annoying, could be reduced)	16
I spent less time on homework	30	Negative comment about the SRL prompts (e.g., distracting, could be reduced)	13
I liked it compared with usual homework	14	Videos lacked entertainment	12
Being able to pause and rewind the instruction	12		

descriptive means and standard deviations in Table 2. These demonstrate that students in the SRL-support condition were on average neutral about the SRL prompts and negatively valued the SRL instruction in the videos. In addition, the students did not perceive that the SRL support caused a change in their metacognitive learning behavior. It should be noted that the standard deviations for all evaluative questions were large, which indicates that the satisfaction of students varied greatly.

Third, to better interpret our findings, we added evaluative questions about how students experienced our FL experiment. When asked how seriously they watched the instructional videos to understand the learning material, students on average answered that they deliberately watched them ($M = 5.50$, $SD = 1.41$, $n = 112$, scale from 1 to 7). Furthermore, in Table 3 we present an overview of students' open answers to the questions asking what they valued positively about FL, and what could be improved. The results confirm the earlier reported findings that students were generally positive about their experience in our FL intervention and that a proportion of the students complained about the SRL support. In addition, students indicated why they did or did not watch the videos and *t*-tests showed no significant differences between the two conditions for each of the motives, as presented in Fig. 1. It appears that, for more than 80% of the students, the bonus point was an important incentive to watch the videos, and the majority watched the videos because they liked the FL method.

4. Discussion

4.1. Effects of SRL support on SRL, learning outcomes, and satisfaction

In the current research intervention in an eight-week flipped History class, eighth-grade students in an SRL-support condition received video-embedded SRL prompts and instruction. We expected that the SRL support would help students to benefit from the FL approach, because the increased learner autonomy that comes with this approach demands SRL skills that most students do not possess. As previous research in the same educational context showed that SRL prompts did not enhance learning outcomes (van Alten et al., 2020), we added explicit SRL instruction to the design of embedded SRL support to explain to students why SRL activities are beneficial, and how they can be performed. We hypothesized that the embedded SRL support enhances students' SRL skills, compared with students in the condition without SRL support and, consequently, enhances their learning outcomes. We found that students in the SRL support condition achieved higher learning outcomes, but, in contrast to our hypothesis, we found no difference in SRL skills as indicated by the SRL self-reports and the SRL online activity variables. We provide several reasons that could explain these findings and would be interesting for future research.

4.1.1. SRL support enhances learning outcomes, but not via (the number of) SRL activities

Previous research has shown that SRL interventions and students' SRL skills are positively related to higher learning outcomes (Dent & Koenka, 2016; Donker et al., 2014). Therefore, studies that test and show positive effects of SRL interventions on learning outcomes assume that these are caused by a positive mediation effect of SRL interventions on learning outcomes by SRL activities (Jansen et al., 2019). However, a meta-analysis showed that SRL activity only partially mediates the effects of SRL interventions on learning outcomes (Jansen et al., 2019). This suggests that there are other factors leading to enhanced learning outcomes resulting from SRL support, apart from improving students' SRL self-reports and activities.

First, this could be explained by an increase in time-on-task for students whose SRL was supported. Due to the SRL support, students could be more aware in the monitoring phase that they had to spend more time on learning because they did not understand parts of the learning material (Belski & Belski, 2014; Jansen et al., 2019). Unfortunately, we could not measure these corrective learning activities outside the online learning environment. It is also possible that some students who received SRL support spend less time on learning and performing SRL activities, because the SRL support enabled them to learn more efficiently. Indeed, some students reported that they valued the FL method because they spend less time on their homework than usual (see Table 3).

Second, the strategy behind our SRL support was to enhance both the quality (i.e., SRL instruction) and the quantity (i.e., SRL prompts) of students' SRL activities (Panadero, Klug, & Järvelä, 2016). However, the extent to which we measured SRL (i.e., log data and self-reports) mainly provides quantitative SRL indications. While we did not find that the effect of SRL support on learning outcomes was due to an increase in the number of SRL activities, it could be possible that our intervention improved the quality of students' SRL activities.

4.1.2. Students were satisfied with FL, but not with the SRL support

Our results show that we can rule out the possibility that we found no effects on SRL because the students lacked the level of satisfaction required to perform SRL activities due to the learning environment (cf. Schuitema et al., 2012). Students from both

research conditions were generally satisfied with the FL environment. The mean score on the satisfaction questionnaire showed a positive value (Table 1), and students from both conditions seem to have similar reasons to watch or not watch the videos (Fig. 1). In addition, the students stated that their effort to learn from the videos was deliberate. The SRL prompt compliance rate also suggests that the students from the SRL-support condition used the prompts properly.

However, students from the SRL-support condition expressed their dissatisfaction with the SRL support in the videos (Tables 2 and 3). The opinions about the SRL prompts were neutral on average, but varied greatly. The opinions about the SRL instructions were clearly negative, although these also varied greatly. In contrast to previous research in the same educational context (van Alten et al., 2020), SRL prompts alone did not enhance learning outcomes. In the current study, we found an effect on learning outcomes when SRL instruction was added, even though the students seem have to generally disliked this type of SRL support. It is important to further investigate students' dissatisfaction with the SRL support. Support seems to work better when students are satisfied and recognize the added value of it, and dissatisfaction may even prevent them from engaging in SRL activities (cf. Schuitema et al., 2012).

We suggest two possible explanations for the results in our study that have important implication for future SRL research in secondary education. First, some direction can be found in students' answers that state that the SRL support should be reduced, because they already knew why and how to apply SRL strategies. Previous research suggested that students in primary education benefit more from SRL interventions as they lack knowledge and experience with SRL, in contrast to students in secondary education (Donker et al., 2014; Lai & Hwang, 2016). It could be that the secondary education students had already acquired a certain level of SRL and that therefore explicit SRL instruction did not enhance their SRL (cf. the expertise reversal effect; Kalyuga, Ayres, Chandler, & Sweller, 2003). However, our results indicate that the added value of SRL instruction to SRL prompts enhances learning outcomes.

Second, it could be that students disliked the SRL support because applying SRL strategies is more difficult than not using them as it requires a certain effort. While students may think SRL support distracts them from learning, we know from research that students tend to misjudge their own learning based on the perceived ease of processing (Bjork, Dunlosky, & Kornell, 2013). The large variation between students in how they valued the SRL support, and also in their performance of online SRL activity (e.g., *rewind actions*), indicates that some students were very positive about the SRL support and some were very negative.

4.1.3. Limitations and directions for future research

The way we operationalized and measured prior knowledge did not explain the variation in effects of SRL support on SRL and learning outcomes. In future research, it would be helpful to include students from different educational tracks. We included students from only the pre-university track, to diminish pre-existing differences between conditions and to accurately measure the effects of the SRL support using comparable samples. However, this track represents only approximately 20% of the student population in the Netherlands. Including students from other tracks would increase the differences in students' prior knowledge and SRL skills. Previous research into the effectivity of FL in secondary education suggested that FL seems to work well only with students who are good at SRL and are sufficiently motivated to benefit from the increased autonomy (Heyma et al., 2015). As the relation between prior knowledge and SRL behavior has been demonstrated in previous research (Schwonke et al., 2013), we recommend that future research investigates how the individual learning processes of a more diverse student population develop during FL, including their SRL activities, satisfaction with the SRL support, how this is related to prior knowledge and other explanatory variables.

It is also possible that we did not find differences in SRL between conditions due to methodological reasons. For example, it is possible that the design of our FL environment also improved the SRL of students in the no-SRL-support condition to such an extent that it was hard to detect any differences between conditions. Meta-analytic research has found that students applying FL improve in terms of SRL in comparison with students in a traditional classroom (Tan et al., 2017). Other research has also shown that students in an authentic context may spontaneously take advantage of the interactive possibilities in terms of SRL activities by manipulating instructional videos (e.g., by pausing or rewinding) without being prompted or instructed (Henderson, Selwyn, & Aston, 2017; Merkt, Weigand, Heier, & Schwan, 2011; Schwan & Riempp, 2004). This is in line with data from Table 3, in which some students stated that they especially valued FL because they could manipulate the instruction presented in the video. The current sample size was large enough to detect a medium effect on learning outcomes, but too small to detect small effects on SRL. Denying the no-SRL-support group access to these interactive design features or the quiz questions in their workbook, which potentially increase the SRL activities of this

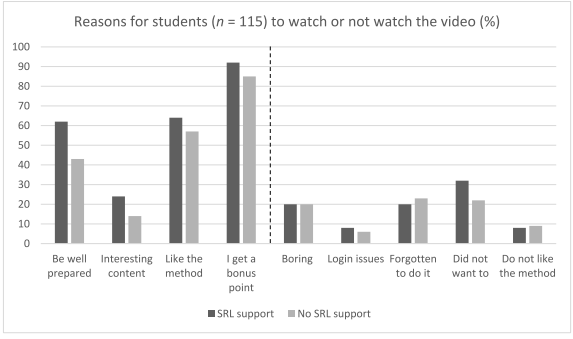

Fig. 1. Percentage of students in the SRL-support (n = 50) and the no-SRL-support (n = 65) conditions who agreed with the statements about reasons why they watched (first four statements) or did not watch (last five statements) the instructional videos.

group, could perhaps have helped in detecting the effects of the SRL support. However, this creates a conflict for researchers between maintaining the different conditions as equally as possible, manipulating the independent variables, the ecological validity of the study, and the associated ethical aspects (Bétrancourt & Benetos, 2018).

In addition, we added a bonus point for students as a reward for watching the instructional videos in time before class. Students stated that this was an important incentive to complete the homework videos (Fig. 1). This greatly reduced the removal of students from the analysis due to non-compliance (cf. van Alten, Phielix, Janssen, & Kester, 2020). However, a negative effect could have been that this bonus made students in the control group somewhat aware of SRL and perhaps obstructed the detection of an effect of the SRL support on the video completion rate because there was little natural variance due to this external motive. Our suggestion for future research is to keep all these factors in mind while designing SRL support interventions and to achieve a balance between detecting effects and obtaining a large enough sample size.

4.2. Implications for practice

Our results show that it is important for teachers and curriculum developers to consider how the SRL of students is supported in FL environments. As FL increases students' autonomy over their learning, it depends on their SRL skills in order to benefit from the possibilities that FL can offer. We demonstrated that combining SRL prompts embedded in instructional videos with SRL instruction enhanced students' learning outcomes. For instance, we prompted students to rewind parts of the instructional videos when they did not understand the content to stimulate the quantity of SRL activities. We recommend the use of open-ended prompt questions, to provoke deeper reflection by the students (e.g., Panadero et al., 2016).

With the SRL instruction, we aimed to improve the quality of students' SRL activities by providing clear instruction about how to perform effective SRL activities and why it supports their learning. As shown in Table A.1, our SRL instruction was short, presented to students at the beginning and/or ending of the video, and focused on different aspects of SRL (e.g., planning, monitoring, setting goals, and environmental structuring). Moreover, as we also found that the students generally disliked the explicit SRL instruction, we advise careful consideration of the frequency and mode of the SRL support, as it could make students dissatisfied when they see it as a distraction or burden. We suggest presenting SRL support in a scaffolding strategy, in which the SRL instruction tips build on each other and are gradually reduced to encourage the students to internalize the SRL strategies instructed (Kollar & Fischer, 2006). In addition, more research is needed on the question of whether SRL support should be tailored according to the different levels of students' SRL skills (e.g., Vanslambrouck et al., 2019). Caution should be taken by presenting SRL support as optional (e.g., for students with better SRL skills), because students do not seem to comply with SRL support if it is not embedded in the learning environment (Clarebout et al., 2010; Jansen et al., 2020).

5. Conclusion

Our study shows that in the context of an eight-week flipped History class in secondary education, supporting students' SRL by explicit instruction and prompts in the instructional videos leads to improved learning outcomes. However, this effect cannot be explained directly by an improvement in SRL skills, as we did not find effects of SRL support on SRL self-reports or online SRL activities. Although the SRL support helped students to be more aware of their own learning, some students clearly disliked the SRL instruction. We conclude that SRL support is beneficial for students' learning, but that it should be carefully designed to prevent this effect from being hampered by students' dissatisfaction.

CRediT authorship contribution statement

David C.D. van Alten: Conceptualization, Methodology, Investigation, Resources, Writing - original draft. **Chris Phielix:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Jeroen Janssen:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Liesbeth Kester:** Conceptualization, Methodology, Writing - review & editing, Supervision.

Declarations of competing interest

None.

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Appendix A

Table A.1
Overview of all the video embedded SRL prompts and the SRL instruction for the SRL-support condition. Hints (in italics) were provided after students answered a that particular SRL prompt. Video length is provided for the no-SRL-support condition and the SRL-support condition.

Video	SRL instruction before	Forethought prompts (start of the video)		Performance prompts (middle of the video)		SRL instruction after	Self-reflection prompts (end of video)
0 – Introduction (05:29/ 05:29)	–	–		–		–	–
1 - Agricultural and demographic revolution (08:45/ 10:40)	Plannin g + monitoring by making use of the cognitive questions	(1) Make a planning for the next knowledge clip in order to be well prepared and prevent running out of time.	(2) Which advices to learn with the KC are useful for you?	(1) You have now learned about the demographic revolution. Answer quiz question 1 in your workbook to test whether you can explain in your own words.	(2) Do you understand what enclosure acts are? In that case, answer quiz question 2 in your workbook. What could you do now if you don't understand it yet?	Learning strategy (summariz e) + help seeking	Describe briefly what your approach has been to learn with this video. Was it a good approach, or are you going to change your learning behavior next time?
2 – Rise of factories (07:09/09:23)	Setting goals	What are your goals when learning from this homework video? Which learning behavior fits your goal best?		Is there any information so far that you did not understand? You can check yourself by answering the quiz questions in your workbook.		Learning strategies (e.g., monitoring understanding) + environmental structuring + time management.	Did you accomplish the goals you have set at the beginning of this knowledge clip? If not, what can you still do to reach them (for example focus on the quiz questions, rewatch, read the textbook)?
3 – The power of steam (06:01/07:55)	Rationale behind metacognition + learning strategies (e.g., spaced practice, how to make notes)	Name a reason why it is important to think about the way you are learning from the videos.		(1) Answer quiz question 1 in your workbook about the benefits of steam power to check your understanding.	(2) Quiz question 3 is about two important developments in transport. Answer this question to know if you understand them, or if you have to watch the previous instruction again.	Rationale behind quiz questions as an effective strateg y + follow up strategies of a student does not know an answer to the monitoring questions (e.g., rewatch video, read textbook, write down question for peers or teacher in class).	Do you understand all the learning content from this video? If you have any questions, write them down in your workbook and bring them to class. *Hint: You can write down questions about the learning content, or about your study approach.*
4 – Factory workers (06:08/06:51)	Environmental structuring (e.g., prevent distractions)	How do you deal with distractions while learning from the videos?		Answer quiz question 1 in your workbook and recall the causes for the poor working conditions and child labor. *Hint: The correct answers to the quiz questions make a nice little summary of what is important learning content. In addition, it helps you monitoring your understanding of the video.*		–	Rate your own concentration while learning from this video. *Hint: If you gave yourself a low rating, what are you going to do next time to improve it?*

(*continued on next page*)

Table A.1 (*continued*)

Video	SRL instruction before	Forethought prompts (start of the video)		Performance prompts (middle of the video)		SRL instruction after	Self-reflection prompts (end of video)
5 - Urbanization (04:03/ 04:40)	Activate prior knowledge	(1) Which two goals to you want to achieve while learning from the coming video? *Hints: for example, you could set goals like understanding the most important learning content, or spent a maximum of 10 min to my homework.*	(2) The previous video was about the poor working conditions in the factories. Look at the title of the current video, and the quiz questions in your workbook; what will be the current video about? How does it connect to the previous video? *Hint: previous video about poor working conditions in the factories, current video about poor living conditions outside the factories.*	Answer quiz question 2 about why urbanization happened in the 19th century. *Hint: Do you ever rewind the video if you have doubts about your answer, or to check your understanding?*		–	Think back to the two goals that you have set at the beginning of the video. Briefly explain whether you have achieved them, and how you accomplished that.
6 - The social issue (08:19/09:09)	–	Have you changed your way of learning from the videos in the past weeks? *Hint: Have you become more aware of your study approach?*		(1) How can you check whether you understand the explanation of trade unions? *Hint:* make quiz question *1/make notes/rewind/ask your teacher or a classmate for help*	(2) Answering quiz question 2 is actually a kind of note taking about the differences between the 3 concepts. Is this something you will do yourself in the next video?	Recapture several SRL instructions (e.g., monitoring strategies and environmental structuring)	Rate your own concentration while learning from this video. *Hint: compare your rating with the previous rating in video 4.*
7 – Modern imperialism (07:47/07:47)	–	This video lasts 07:47 min and you will also need some time to answer the questions and make notes. Have you planned enough time for this? Are you working in a quiet place where you can concentrate well?		(1) Answer the quiz questions that belong to modern imperialism ask yourself whether you now understand the difference between imperialism and modern imperialism.	(2) You now know that in the following part an explanation of three major causes of modern imperialism will be provied. How will you ensure that you understand and remember this? *Hint: Pause the video after each cause and summarize the cause in your workbook. Rewind if it goes too fast. Explain in your own words. In this way, you remember it better for the test.*	–	Think about some advantages and disadvantages of learning from the videos and how you have experienced this during the past few weeks. Do you think that you are better prepared for the test this way?

Note: The length of the video is provided in this column for subsequently the no-SRL support condition and the SRL support condition.

Appendix B

Table B.1
Internal-Consistency Reliabilities of the Contextualized SOL-Q-R Scales

Scale	pretest			posttest		
	n	Items	α	*n*	Items	α
Metacognitive activities before	111	4	.80	110	5	.75
Metacognitive activities during	111	6	.65	113	6	.71
Metacognitive activities after	113	4	.83	112	4	.86
Persistence	113	5	.82	111	5	.82
Help seeking	109	4	.77	112	4	.83
Environmental structuring	112	3	.51	113	3	.36
Time management	112	4	.72	113	4	.59

Table B.2
Internal-Consistency Reliabilities of the Contextualized MSLQ Scales

Scale	*n*	Items	α
Intrinsic goal orientation	112	4	.69
Extrinsic goal orientation	111	4	.73
Task value	113	4	.90
Expectancy: self-efficacy for learning	112	4	.82

Table B.3
Goodness-of-Fit Indicators of Satisfaction Questionnaire model

Model	*n*	χ^2	*p*-value	*df*	χ^2/df	RMSEA	CFI	TLI
Satisfaction (one factor)	148	15.37	.081	9	1.71	0.07	.98	.97

Note: a non-significant χ^2 suggests model acceptance; *df* = degrees of freedom; χ^2/df should be lower than 3; RMSEA = Root Mean Square Error of Approximation and should be < 0.08; CFI = Comparative Fit Index and should be > 0.95; TLI = Tucker Lewis Index and should be > 0.95.

Table B.4
Pearson Correlation Matrix for all the Dependent Variables (N between 113 and 115)

Dependent variable	MAb	MAd	MAa	PER	HS	TM	VCR	VTI	RA	LO
Metacognitive activities before (MAb)	–									
Metacognitive activities during (MAd)	.633**	–								
Metacognitive activities after (MAa)	.746**	.714**	–							
Persistence (PER)	.142	.467**	.268**	–						
Help seeking (HS)	.428**	.494**	.419**	.439**	–					
Time management (TM)	.336*	.526**	.466*	.496**	.481**	–				
Video completion rate (VCR)	-.002	.032	-.106	.116	.152	.249**	–			
Video timing (VTI)	.030	.081	.081	.100	.129	.153	.789**	–		
Rewind actions (RA)	.171	.051	.134	-.005	.001	-.007	.111	.153	–	
Learning outcome test (LO)	-.080	.170	.045	.289**	.107	.226*	.117	.181	.173	–
Satisfaction (SAT)	.289**	.450**	.340**	.504**	.393**	.541**	.319**	.160	.080	.183

*p < 0.05 (1-tailed).
**p < 0.01 (1-tailed).

Table B.5
Mean and Standard Deviation for the Dependent Variables per Condition and *P*-values of the Analyses.

Pretest variables	SRL-support condition			No-SRL-support condition		
	n	M	SD	n	M	SD
SRL self-report scales (p = .619)						
Metacognitive activities before	50	2.83	1.20	65	2.89	1.18
Metacognitive activities during	50	4.00	0.79	65	3.74	1.09
Metacognitive activities after	50	2.95	1.13	65	2.89	1.30
Persistence	50	4.34	1.27	65	4.29	1.19
Help seeking	50	4.77	1.31	65	4.58	1.22
Time management	50	4.06	1.36	65	3.89	1.29
Motivation self-report scales (p = .028)						
Intrinsic goal orientation	50	4.03	1.09	65	3.63	1.18
Extrinsic goal orientation	50	4.62	1.45	65	4.69	1.19
Task value*	50	4.27	1.52	65	3.53	1.44
Expectancy: self-efficacy for learning	50	4.71	1.25	65	4.67	1.06
Cognitive abilities (p = .337)						
Pre-knowledge test (range: 0–14.5)	43	9.71	1.56	64	9.56	1.76
History performance level (range: 0–10)	50	7.12	1.04	65	6.81	1.12

*p < 0.05.[a]

[a] Note: Provided *p*-values are from the separate (M)ANCOVAs, and for the follow up ANOVA in the case of task value.

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