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Effects of Self-Regulated Learning Prompts at Three Different Phases in Video-Based Learning

Jiahui Wang[1] · **Hengtao Tang**[2]

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Abstract
The current study examined the influences of self-regulated learning prompts provided during three different self-regulated learning phases in video-based learning. A total of 58 college students from a midwestern university were randomly assigned into one of the four conditions: (1) self-regulated learning prompts at the forethought phase, (2) self-regulated learning prompts at the performance phase, (3) self-regulated learning prompts at the self-reflection phase, and (4) no self-regulated learning prompts in any phase. Participants watched a video on the human respiratory system and responded to the self-regulated learning prompts in one of the three phases or no prompts. Upon completing the video, participants responded to a questionnaire assessing their self-regulated learning levels and learning outcome. Self-regulated learning levels were also inferred by learners' behavior of pausing and rewinding during video-watching. Results indicated that participants who received self-regulated learning prompts at the performance phase achieved better learning outcome compared to those in the no prompt condition.

Keywords Video-based learning · Self-regulated learning prompts · Learning outcome · Pauses and rewinds

Introduction

The past decade has witnessed the rapid expansion of online learning worldwide (Seaman et al., 2018). Particularly, the COVID-19 pandemic has significantly expanded the offerings of online education in formal and informal education settings at various levels. During the pandemic, many schools explored flexible online learning options, as attending traditional brick-and-mortar schools may have exposed students to potential health risks. Despite the challenges faced by teachers and students, the prompt responses from the teacher educators allowed for relevant adaptations in their instructions to address the challenges posed by the pandemic (Ferdig et al., 2020). The transitions to emergency remote online learning in response to the pandemic also motivated educators to explore more online learning platforms and technological tools in their instruction, and video has been commonly used in online education to deliver content to learners (Oliveira et al., 2019).

The shift to online teaching and the proliferation of online education after the pandemic highlighted the need to create engaging and effective online learning experiences for all learners (Gherghel et al., 2023). As an increasing number of learners engage in online learning and watch more and more videos online, the need to design videos that not only facilitate learning but also actively engage learners is growing more than ever. As such, it is crucial to conduct more research on instructional support to promote learning and engagement in videos.

The increased autonomy in video-based learning demands self-regulated learning (Delen et al., 2014). Self-regulated learning is defined as "self-regulated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals" (Zimmerman, 2000). In video-based learning where learners have greater autonomy and responsibility for their learning, it is crucial to address the role of self-regulated learning. With the goal of providing engaging online videos for students, the current study focused on examining the effects of self-regulated learning prompts on the levels of self-regulated learning exhibited by students

✉ Jiahui Wang
jwang79@kent.edu

[1] School of Teaching, Learning and Curriculum Studies, College of Education, Kent State University, Health, and Human Services150 Terrace Dr, Kent, OH 44243, USA

[2] Department of Educational Studies, College of Education, University of South Carolina, Columbia, SC, USA

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and the learning outcome they achieve while engaging with videos online.

Literature Review

Online Video and Engagement

Despite the increasing prevalence of online education, the inherent transactional distance in online education presents challenges for online learners. Evidence shows online courses still have much higher in-session dropout (Chen et al., 2017; Vitiello et al., 2018), low engagement (Kim et al., 2014; Krause et al., 2015), and lower completion rates (Chuang & Ho, 2016) compared to similar courses offered in traditional face-to-face classrooms. The reasons for high dropout rates in online learning environments are many and complex; however, lack of sustained student motivation to study alone (Hart, 2012), inadequate student-instructor interaction (Glassman et al., 2015; Kleftodimos & Evangelidis, 2016), lack of learner personalization (Brinton et al., 2015; Raghuveer et al., 2014), and insufficient feedback and support in the time of student disengagement (Grawemeyer et al., 2016) have been identified as crucial factors that could restrict the effectiveness of online learning. Among all the learning activities that occur in the online environment, video represents the primary means of information delivery (Oliveira et al., 2019), and it could exacerbate the above-mentioned problems. Considering the unidirectional nature of today's online videos, video-based learning could become passive if no active engagement of learner is provided within the video (Harrison, 2020; Long et al., 2023). To maximize learning from videos, students would need to actively engage in the self-regulated learning processes instead of passively taking in the information from the video. As such, well-designed videos that facilitate the self-regulated learning processes present a promising direction for fostering students' learning and engagement in video-based learning.

Self-Regulated Learning

Given the unidirectional nature of online videos and the emphasis on student autonomy, self-regulated learning is critical when watching videos online. Self-regulated learning strategies (i.e., metacognition, time management, effort regulation, and critical thinking) have been found to significantly influence learning in the online setting (Broadbent & Poon, 2015). Research has suggested that learners' monitoring of their learning processes and use of self-regulated learning strategies are positively associated with their learning outcomes in multimedia environments (Azevedo, 2014).

Three Phases of Self-Regulation

Zimmerman (2000) proposed the self-regulated learning model that provides a comprehensive framework for understanding the dynamic process of self-regulated learning. This model is comprised of three cyclical phases: forethought, performance, and self-reflection. Each phase plays a crucial role in influencing the effectiveness of self-regulated learning.

The first phase, known as forethought, serves as the foundation upon which successful self-regulated learning is established. During this initial phase, learners conduct a thoughtful analysis of the learning tasks. They deliberate on what needs to be achieved and set goals. Furthermore, learners engage in strategic planning of the steps they will take to accomplish their goals. Within the forethought phase, several motivational beliefs are theorized to influence the process and activation of self-regulated learning strategies, which include self-efficacy, task value, outcome expectations, and goal orientation. More specifically, self-efficacy reflects learners' belief in their own ability to succeed in the tasks (Bandura, 1993). Zimmerman (2000) suggested that learners with high self-efficacy are more likely to utilize effective learning strategies, self-regulate their learning processes efficiently, and achieve desired learning outcomes. Task value comes into play as learners evaluate the significance and relevance of the learning activities to their goals. Wigfield and Eccles (2000) found perceived task value possibly correlated with effort and persistence in completing the learning task and academic achievement. Outcome expectations, or the anticipation of what will result from their efforts, contribute to the motivation to engage in self-regulated learning. Additionally, learners' goal orientation, the degree to which the learners work toward achieving specific goals, influences the self-regulated learning strategies they will employ.

As learners move onto the performance phase, they begin to put their plans into action. In this phase, they actively participate in the learning tasks, while monitoring their progress. Learners utilize a variety of self-regulated learning strategies such as summarizing, self-instruction, note-taking, time management, and help-seeking in this phase of self-regulated learning. Research has found that effective metacognitive self-regulation is associated with improvement in learning outcomes (Schraw & Moshman, 1995).

The final phase is self-reflection, where learners engage in critical assessment on their task performance and reflect upon the reasons behind their successes or failures. Positive or negative reactions generated during this phase may influence their future motivational beliefs and task performance. Successes may enhance self-efficacy and

reinforce task value, while failures may prompt learners to re-evaluate their goals and strategies.

Self-Regulated Learning Prompts in Video

Self-regulated learning prompts are designed to support learners in performing specific activities while learning (Wirth, 2009). In a recent meta-analysis, Guo (2022) demonstrated that self-regulated learning prompts in computer-based learning environments significantly enhanced self-regulated learning activities and learning outcomes compared to control conditions.

Given the challenges in video-based learning and its unidirectional nature, previous work has explored the use of self-regulated learning prompts in video-based learning (Moos & Bonde, 2016; van Alten et al., 2020). Research has suggested that self-regulated learning prompts may successfully engage learners in the self-regulatory processes during video-based learning and positively affect learning outcomes (Moos & Bonde, 2016). More specifically, in Moos and Bonde (2016)'s study, participants watched a video on *theories of motivation* with self-regulated learning prompts during the three phases of self-regulated learning (i.e., forethought, performance, and self-reflection) and self-reported the self-regulated learning strategies that occurred during the video using a think-aloud. The findings from the study indicated those who received self-regulated learning prompts engaged in more self-regulatory learning activities with better quality. These self-regulatory learning activities included activating prior knowledge and monitoring understanding during the video. Those who did not receive the self-regulated learning prompts rarely engaged in self-regulatory behavior. Regarding the effect of self-regulated learning prompts on learning, the results indicated that those who received self-regulated learning prompts at the three phases of self-regulated learning excelled on the learning test. In sum, the self-regulated learning prompts overall had a positive effect on self-regulated learning strategies and subsequent learning outcomes.

In a subsequent study, van Alten and colleagues (2020) examined the effects of self-regulated learning prompts in a flipped class on learning outcomes, satisfaction, and self-regulated learning. The study indicated that the self-regulated learning prompts had a positive influence on the videos' completion rate but were not found to affect self-regulated learning or learning outcomes.

Frequency of Self-Regulated Learning Prompts

Empirical research has suggested that the timing of providing self-regulated learning prompts would have a differential effect on learning. For example, Thillmann and colleagues (2009) examined the timing of prompts in self-regulated learning in a relevant context (i.e., a computer-based learning program on physics). The participants were provided with the same self-regulated learning prompts, but the presentation time of the self-regulated learning prompts in relation to the learning task differed among the three groups: before learning, during learning, and adapting the presentation of prompts based on an optimal course of learning regulation. With regard to the comparison between prompts provided before and during learning, data suggested that presenting prompts during learning positively affected learning outcomes compared to presenting prompts before learning.

Additionally, Moos and Bonde (2016), whose study examined the overall effects of self-regulated learning prompts in video-based learning, suggested it may not be necessary to prompt all the phases considering the interactive nature of the three phases (i.e., forethought, performance, and self-reflection) of self-regulated learning.

Moreover, van Alten and colleagues (2020) suggested that some students clearly disliked the self-regulated learning prompts. The learners perceived the self-regulated learning prompts as distracting them from learning and wanted the prompts to be reduced. Therefore, van Alten and colleagues (2020) suggested practitioners should carefully consider the frequency of providing self-regulated learning prompts, to avoid dissatisfaction from students.

In sum, the existing evidence suggested that the three phases of self-regulated learning are interactive and that learners appreciated fewer self-regulated learning prompts during the learning task. Therefore, the current study hypothesized that it might not be necessary to prompt all three phases of self-regulated learning and that videos could just provide self-regulated learning prompts in one phase to an extent to not cause distractions for learners.

Studying Self-Regulatory Learning Processes

Most of the existing research has largely relied on the subjective report of self-regulatory behavior and strategies associated with learning with videos. Widely used self-reported measures include the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich and DeGroot (1990) and the Learning and Study Strategies Inventory (LASSI) developed by Weinstein et al. (1987). While these measures may be useful and efficient in gauging broad self-regulatory behavior and strategies, they may be insufficient to study the complex and dynamic self-regulatory processes that underlie video-based learning.

The current study was designed to address this gap by investigating the underlying self-regulated learning processes in addition to the self-reported measure of self-regulated learning. Research has suggested process data is useful in detecting learners' self-regulated learning behavior (Maldonado-Mahauad et al., 2018). The use of log data may

provide a way to trace and detect students' self-regulated learning processes. For example, in a relevant multimedia learning environment (e.g., MetaTutor), learners' log data while using the system was collected to infer their self-regulated learning processes (Azevedo et al., 2010). In the context of video-based learning, the use of process-oriented measures would provide insights into the underlying self-regulated learning processes while learners watch the video. More specifically, pauses and rewinds have been shown to represent deliberate actions of self-regulated learning in video (Jansen et al., 2020). When learners do not understand something in the video and would like to cognitively process it for a longer period of time, they may pause or rewind the video to further their comprehension of the video content (Jansen et al., 2020; Maldonado-Mahauad et al., 2018). Therefore, the current study used learners' behavior of pausing and rewinding during video-watching as a process-oriented measure of self-regulated learning.

Current Study

To address gaps in the literature, the current study was designed to examine how prompting self-regulated learning at different phases may impact self-regulated learning levels and learning outcome in video-based learning. In addition to using the self-report measure of self-regulated learning levels, the study also measured the underlying self-regulated learning levels based on the process-oriented data (i.e., pauses and rewinds) during video-based learning. This approach aimed to provide a comprehensive assessment of self-regulated learning in video-based learning and a nuanced understanding of self-regulated learning dynamics during video-based learning. Moreover, the current study examined learners' perceptions of self-regulated learning prompts provided at three different phases in video-based learning: forethought, performance, and self-reflection. By examining the learners' perspectives regarding self-regulated learning prompts at different phases, the study aimed to gain insights into how learners perceived self-regulated learning prompts and provide practical implications for incorporating self-regulated learning prompts in video-based learning. The following three research questions were addressed in the current study:

- *RQ1*: How do three phases of self-regulated learning prompts (i.e., forethought, performance, and self-reflection) embedded in a video affect college students' learning outcome?
- *RQ2*: How do three phases of self-regulated learning prompts (i.e., forethought, performance, and self-reflection) embedded in a video affect college students' levels of self-regulated learning?
- *RQ3*: How do learners perceive three phases of self-regulated learning prompts (i.e., forethought, performance, and self-reflection) embedded in a video?

Method

In the present study, an experimental design was utilized as this design could effectively assess the impact of the independent variable on the dependent variables (Creswell & Guetterman, 2018). We implemented a true experiment design, randomly assigning participants into treatment and control conditions.

Participants

The study was approved by the institutional review board of the author's university. The current study was advertised to undergraduate students who were enrolled in an introductory-level course in educational technology. A total of 58 students participated in the current study ($M_{age} = 20.86$, $SD_{age} = 2.21$). Participants included 54 females and 4 males. Participants' majors included early childhood education, middle childhood education, art education, language arts, and social studies education.

Intervention

Video

The video on the human respiratory system consisted of ten slides, and each slide was accompanied by a narration. The content for the narration was developed based on the text used in previous work focusing on the human respiratory system (Leopold & Mayer, 2015). The ten slides focused on the following: (1) Introduction, (2) Structure of the Nervous System, (3) Steps in the Nervous System to Control Breathing, (4) Structure of the Thoracic Cavity, (5) Structure of the Airway System, (6) Process of Inhaling, (7) Structure of the Exchange System, (8) Structure of the Circulatory System, (9) Process of Exchanging, and (10) Process of Exhaling.

Self-Regulated Learning Prompts

The self-regulated learning prompts were adapted from Moos and Bonde (2016) focusing on the three phases of self-regulated learning: forethought, performance, and self-reflection (Zimmerman & Moylan, 2009). Participants were randomly assigned to watch the video under one of the following four conditions: (a) self-regulated learning prompts at the forethought phase (e.g., before watching the video, what questions do you have about the human respiratory system?); (b) self-regulated learning prompts at the

performance phase (e.g., what information have you learned so far?); (c) self-regulated learning prompts at the self-reflection phase (e.g., what did you learn about the human respiratory system?); and (d) control condition without any self-regulated learning prompts.

Procedures

After signing the informed consent and agreeing to participate, participants first responded to a Qualtrics survey focusing on (1) demographic information (i.e., gender, age, major) and (2) prior knowledge of the video topic.

After completing the pre-video survey, participants were randomly assigned to one of the four conditions with the corresponding instruction for each condition (self-regulated learning prompts at the forethought phase, self-regulated learning prompts at the performance phase, self-regulated learning prompts at the self-reflection phase, no self-regulated learning prompts). The randomization was afforded by the randomizer tool in Qualtrics.

In each condition's instruction, participants were provided the link to Edpuzzle (https://edpuzzle.com/), where they viewed the video and responded to the self-regulated learning prompts if assigned to the conditions with self-regulated learning prompts. Edpuzzle was selected because it could present the video, record participants' video-watching behavior (i.e., pausing and rewinding activities), and collect participants' responses to the self-regulated learning prompts.

Participants were given the join code to Edpuzzle as well as the sign-up information consisting of the randomly assigned ID code. In this manner, the researchers were able to link each participant's assigned experimental condition, their responses to the questions on the Qualtrics survey, video-watching behavior on Edpuzzle, and responses to the self-regulated learning prompts embedded in the video.

Based on the conditions the participants were assigned to, they watched the video and responded to self-regulated learning prompts embedded in the beginning, middle, or end of the video or watched the video without responding to any self-regulated learning prompts. The self-regulated learning prompts were forced open-ended questions that participants were required to answer. After examining participants' responses to the self-regulated learning prompts in Edpuzzle, we concluded that the participants worked properly with the self-regulated learning prompts in the experimental conditions. The total length of the video without any learner control (i.e., pauses or rewinds) and responding to the self-regulated learning prompts lasted 4 min and 42 s. Participants were also instructed to watch the video at their own pace. Although the participants were not allowed to fast-forward the video, they were given the self-control to be able to pause, rewind, and re-watch any part of the video. A logging program was used to record participants' self-regulatory behaviors as they watched the video. Participants were instructed to pay great attention to the video as they would be assessed on the material upon completing the video. They were also instructed not to take notes during the video. Upon finishing the video, participants responded to the questions on the post-test, which included questions assessing learning outcomes and self-regulated learning levels, as well as two open-ended questions on their perceptions of the self-regulated learning prompts in the video.

Measures

Prior Knowledge

Previous research indicated that learners with varied levels of prior knowledge benefited differently from self-regulated learning prompts (Yeh et al., 2010). Furthermore, students possessing a higher level of prior knowledge were found to engage in more self-regulated learning processes compared to their lower prior knowledge counterparts (Taub et al., 2014). To avoid the impact of pre-existing difference in students' prior knowledge of the human respiratory system, a questionnaire consisting of 12 statements (Leopold & Mayer, 2015) was adopted to measure participants' prior knowledge. Participants were instructed to select all the statements that applied to them. The statements included the following: (1) I have participated in science programs or fairs; (2) biology was my favorite subject in high school; (3) I sometimes watch science documentaries about anatomy in my free time; (4) I can name most of the parts of the human heart from memory; (5) I have taken a course in human anatomy or physiology; (6) I attended a course on cardiopulmonary resuscitation (CPR); (7) I can explain what pulmonary embolism means; (8) I sometimes find myself on the Internet looking up biology-related topics; (9) I have watched an educational video on how the respiratory system works; (10) I talked to a doctor about the process of how respiration works; (11) I know what the terms "diastolic" and "systolic" mean; and (12) I took advanced biology courses in high school (AP, IB, Honors). The total number of applicable statements was used to represent participants' prior knowledge of the human respiratory system. Participants' prior knowledge scores ranged from 1 to 9 out of 12 ($M = 2.34$, SD = 1.63), which indicated a low level of prior knowledge related to the topic to be learned in the video. The ANOVA test on the prior knowledge scores across the four groups indicated that the participants assigned to the four groups were not significantly different in their levels of prior knowledge related to the topic, $F\,(3, 54) = 1.961$, $p = 0.131$, partial $\eta^2 = 0.098$.

Learning Outcome

The measure of learning outcome consisted of five items adopted from a previously validated instrument (Leopold & Mayer, 2015). The total score of the five items was used to represent the learning outcome from the video.

The questions on the learning test required the learners to apply what they have learned from the video to new situations and solve new problems. An example question resembled the following: *Although there is oxygen in the lungs, the cells in the body do not get enough oxygen to make energy. What could have caused this problem?* One point was awarded for each correct response, and 0 points were awarded for an incorrect answer. Two trained raters scored the correctness and completeness of the answers to the questions on the test. Disagreement was resolved via discussion. The internal consistency for the five items was Cronbach's alpha = 0.579. The reliability coefficient is slightly below the expected level, likely due to the small number of questions utilized for the scale.

Process Measure of Self-Regulated Learning Levels

Pauses and rewinds during video-watching were used to measure participants' self-regulatory learning processes. Video interaction logs were analyzed to infer the number of pauses and rewinds. While watching the video, participants were given self-control to be able to pause and rewind the video. They could rewind each time for 15 s by clicking the rewind button. The play bar was designed to indicate the progression of the video, but it was not controllable by the participant. Participants' rewinding and pausing behaviors were calculated as the extra number of times the video portions were viewed. The video had ten segments, and if the learner did not do any pausing or rewinding during these ten segments, the total number of times the video segments watched would be 10. For example, if the 10th segment was watched two times, the total number of video segments watched would be 11. Then, the difference would be 1, and this number was used to represent the occurrences of pausing and rewinding behavior during the video.

Self-Reported Self-Regulated Learning Levels

To measure participants' self-regulated learning levels, the Motivated Strategies for Learning Questionnaire (MSLQ, Pintrich & DeGroot, 1990) was adapted for the current study. MSLQ has been commonly used to measure self-regulated learning in previous studies (Van den Boom et al., 2007). The questions focused on aspects of the questionnaire relevant to the current context (i.e., video-based learning). Aspects not relevant to video-based learning were not included in the questionnaire. Six questions focused on task value (e.g., "It is important for me to learn the subject matter in this video"), four questions on self-efficacy (e.g., "I am confident I can understand the basic concepts presented in the video"), and six questions on metacognitive self-regulation (e.g., "I ask myself questions about how well I am doing while learning from the video"). Participants were instructed to rate their level of agreement with these statements on a 7-point Likert scale ranging from *strongly disagree* (1) to *strongly agree* (7). Internal consistency for task value, self-efficacy, and metacognitive self-regulation is $\alpha = 0.911$, $\alpha = 0.772$, and $\alpha = 0.734$, respectively.

Perceptions of Self-Regulated Learning Prompts

Participants were told they would watch the video with or without the self-regulated learning prompts in the informed consent. For those participants who watched the video with self-regulated learning prompts at three different phases, an additional open-ended question was posed to gauge participants' perceptions of the provision of the self-regulated learning prompts in the video (i.e., *How do you feel about the self-regulated learning prompts? Please respond to this question only if you have watched the video with self-regulated learning prompts. If you have watched the video without the self-regulated learning prompts, please type "N/A"*). It was also of interest to examine what other kinds of support participants would expect to have while watching the video besides self-regulated learning prompts. As such, another question was asked for all the participants in the four conditions: "*What other kinds of support can benefit you in learning from the video? Please respond to this question no matter if you have watched the video with self-regulated learning prompts or not*."

Results

Assumptions were checked before analyzing the data using ANOVA models. Normality was examined by using skewness, kurtosis, and Shapiro–Wilk test values and also by inspecting the histograms and boxplots. Homogeneity of variance was tested by Levene's test of equality of error variances. The assumption of independence was checked by examining the scatterplots. No violations of assumptions of normality, homogeneity of variance, or independence were found. We compared the means of learning outcome and self-regulated learning levels (via pauses and rewinds and self-report) among four conditions: (1) self-regulated learning prompts at the forethought phase, (2) self-regulated learning prompts at the performance phase, (3) self-regulated learning prompts at the self-reflection phase, and (4) no self-regulated learning prompts. Results are organized

Table 1 Descriptive statistics on learning outcome

Condition	Mean	SD
Self-regulated learning prompts at the forethought phase	3.27	1.03
Self-regulated learning prompts at the performance phase	3.86	0.95
Self-regulated learning prompts at the self-reflection phase	3.00	1.20
No self-regulated learning prompts	2.93	1.49

Table 2 Descriptive statistics on pauses and rewinds

Condition	Mean	SD
Self-regulated learning prompts at the forethought phase	4.27	4.45
Self-regulated learning prompts at the performance phase	3.29	5.09
Self-regulated learning prompts at the self-reflection phase	1.67	2.47
No self-regulated learning prompts	2.30	2.92

according to the three research questions guiding the current study.

RQ1: How Do Three Phases of Self-Regulated Learning Prompts (i.e., Forethought, Performance, and Self-Reflection) Embedded in A Video Affect College Students' Learning Outcome?

Participants who received self-regulated learning prompts at the performance phase achieved better learning outcome than those in the no prompts condition (see Table 1). The ANOVA test indicated the participants in the four conditions did not differ significantly in their learning outcome, F (3, 54) = 1.797, p = 0.159, partial η^2 = 0.091. The LSD post hoc analysis indicated a significant difference in learning outcome between the participants who received self-regulated learning prompts at the performance phase compared to those without any prompts, MD = 0.93, p = 0.043.

RQ2: How Do Three Phases of Self-Regulated Learning Prompts (i.e., Forethought, Performance, and Self-Reflection) Embedded in A Video Affect College Students' Levels of Self-Regulated Learning?

Influence of Self-Regulated Learning Prompts on Pauses and Rewinds

The descriptive statistics on pauses and rewinds in the four conditions can be gleaned in Table 2. We found no significant main effect of prompt condition on participants' pauses and rewinds during video-watching, F (3, 54) = 1.293, p = 0.286, partial η^2 = 0.067.

Influence of Self-Regulated Learning Prompts on Self-Reported Self-Regulated Learning Levels

The descriptive statistics on the self-reported self-regulated learning levels are displayed in Table 3. The ANOVA test suggested there was no significant effect of self-regulated learning prompt condition on the self-reported task value, F (3, 54) = 1.397, p = 0.254, partial η^2 = 0.072; self-efficacy, F (3, 54) = 0.724, p = 0.542, partial η^2 = 0.039; metacognitive self-regulation, F (3, 54) = 0.394, p = 0.758, partial η^2 = 0.021; or the total score of self-reported self-regulated learning levels, F (3, 54) = 1.173, p = 0.329, partial η^2 = 0.061.

RQ3: How Do Learners Perceive Three Phases of Self-Regulated Learning Prompts (i.e., Forethought, Performance, and Self-Reflection) Embedded in A Video?

Participants' responses to the two questions (i.e., *How do you feel about the self-regulated learning prompts? Please respond to this question only if you have watched the video with self-regulated learning prompts. If you have watched the video without the self-regulated learning prompts, please type "N/A"; What other kinds of support can benefit you in learning from the video? Please respond to this question no matter if you have watched the video with self-regulated learning prompts or not*)

Table 3 Descriptive statistics on self-reported self-regulated learning levels

Condition	Task value	Self-efficacy	Metacognitive self-regulation	Total score
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Self-regulated learning prompts at the forethought phase	29.93 (7.77)	15.73 (3.94)	16.20 (6.30)	61.87 (14.34)
Self-regulated learning prompts at the performance phase	25.57 (9.33)	14.79 (4.53)	13.93 (7.55)	54.29 (17.03)
Self-regulated learning prompts at the self-reflection phase	24.93 (7.04)	14.60 (4.42)	13.93 (6.57)	53.47 (14.85)
No self-regulated learning prompts	25.29 (6.23)	13.43 (4.00)	15.29 (6.72)	54.00 (9.42)

have been analyzed, and themes have been identified. The identified themes are summarized in Table 4.

Besides the feelings toward the self-regulated learning prompts (see Table 4), it is also important to discuss the feedback received from participants regarding their preferences for the timing of self-regulated learning prompts when responding to the second question.

The participants who did not receive the self-regulated learning prompts in the middle of the video mentioned that they would appreciate the self-regulated learning prompts in the middle of the video instead ($N = 1$ from the no prompts group; $N = 1$ from the group receiving self-regulated learning prompts during the self-reflection phase). Furthermore, two participants who received self-regulated learning prompts during the performance phase expressed their appreciation of the self-regulated learning prompts in the middle of the video.

However, it is crucial to acknowledge that not all participants favored the self-regulated learning prompts. One participant's response suggested that these self-regulated learning prompts provided at the beginning of the video had an unintended consequence. For this participant, the need to consider and respond to the self-regulated learning prompts introduced at the beginning of the video added stress to the learning process, potentially hindering their ability to engage with the video effectively. This finding suggested that self-regulated learning prompts are not always favored by the students, and it is important to take individual learner needs and preferences into account when providing self-regulated learning prompts in videos (Schwam et al., 2021).

Discussion

The current study was designed to explore the effects of providing self-regulated learning prompts at three different phases on students' learning outcome and self-regulated learning levels (measured by self-report and pauses and rewinds) in video-based learning. The findings indicated that the self-regulated learning prompts at the three phases did not have a differential effect on learners' behavior of pauses and rewinds or the self-reported self-regulated learning levels. The learning outcome was found to be different between those who received self-regulated learning prompts at the performance phase and those in the no self-regulated learning prompt condition. The current study advanced our understanding of the influences of self-regulated learning prompts in three phases of self-regulated learning (i.e., forethought, performance, and self-reflection) on learning outcome and self-regulated learning levels while watching a video.

Influence of Self-Regulated Learning Prompts on Learning Outcome

The quantitative data of the current study indicated that self-regulated learning prompts at the performance phase had a positive effect on learning outcome compared to the no prompts condition. The positive effect on learning outcome was not replicable to the conditions where participants responded to the self-regulated learning prompts at other two phases (i.e., forethought and self-reflection). The possible explanation is that providing the self-regulated learning prompts in the middle of the video could better allow learners to monitor their learning progress, check

Table 4 Results on participants' perceptions of self-regulated learning prompts

	How do you feel about the self-regulated learning prompts?	What other kinds of support can benefit you in learning from the video?
Self-regulated learning prompts at the forethought phase ($N = 15$)	• Help me focus ($N = 3$) • Help check understanding and look for info ($N = 1$) • Make it more stressful ($N = 1$) • Not like it ($N = 1$)	• Note taking ($N = 11$) • Quiz ($N = 11$) • Provide captions ($N = 5$) • Provide workbook/worksheet to fill in while watching the video ($N = 3$)
Self-regulated learning prompts at the performance phase ($N = 14$)	• Help focus and retain more information ($N = 3$) • Help reflect/check understanding and look for info ($N = 6$) • Not like it/not helpful/distracting ($N = 3$)	
Self-regulated learning prompts at the self-reflection phase ($N = 15$)	• Help check understanding and look for info ($N = 3$) • It is necessary ($N = 1$) • It makes info clear ($N = 1$)	
No self-regulated learning prompts ($N = 14$)	N/A	

their understanding of the content, and look for information actively, therefore contributing enhanced learning outcome (Moos & Bonde, 2016). Providing self-regulated learning prompts during the forethought and the self-reflection phases may not effectively influence the use of self-regulated learning strategies and learning outcome due to their timing. The qualitative findings from the responses to the open-ended questions also provided some evidence that providing self-regulated learning prompts at the performance phase was most favored by the participants.

Measures of Self-Regulated Learning

The current study examined learners' self-regulatory levels, via digging into the process-oriented data (i.e., video interaction logs) during video-based learning. As the study examined the feasibility of objectively measuring students' self-regulatory processes, the research advanced the science of assessment of self-regulated learning in videos. The results also contributed new knowledge to our understanding of the underlying self-regulated learning processes in videos.

The study provided important implications for designing adaptive videos that could enhance the self-regulated learning processes and learning outcome. The methodology of measuring self-regulated learning processes in videos contributed to the potential for designing and developing new educational technologies that call for self-regulated learning. The findings from the current study also offered important practical implications for the design of videos in general, which are included in a multitude of massive online learning interfaces, such as Coursera, Khan Academy, and EdX, just to name a few.

Influence of Self-Regulated Learning Prompts on Self-Regulated Learning Levels

The qualitative data indicated that self-regulated learning prompts encouraged participants to monitor their own learning and in general were appreciated by the students. It is possible that the way self-regulated learning was measured in the current study (i.e., self-report; pauses and rewinds) mainly provided quantitative indications of self-regulated learning and may fail to capture the nuances in the quality of self-regulated learning activities. Although the current findings did not show any significant effects of self-regulated learning prompts on the self-reported self-regulated learning levels or activities of pausing and rewinding, we could conclude from the qualitative data that learners appreciated the presence of the self-regulated learning prompts, especially the self-regulated learning prompts in the performance phase. It could be possible that learners have been previously exposed to self-regulated learning strategies and even though no self-regulated learning prompts were provided in the control condition, they would still apply some self-regulated learning strategies when watching the video. Future research is recommended to consider more individual difference factors besides prior knowledge, for example, pre-existing self-regulated learning abilities (Vanslambrouck et al., 2019), as these variables could possibly influence the use of self-regulated learning strategies with the support of self-regulated learning prompts.

Practical Implications

Video demands an increased level of autonomy from students, and learning from video is dependent on learners' self-regulated learning skills. Findings from the study demonstrated that providing self-regulated learning prompts in the performance phase enhanced students' learning outcome compared to not providing any self-regulated learning prompts in any phase. The finding along with participants' feedback regarding the timing of self-regulated learning prompts provided rudimentary evidence that videos could consider providing self-regulated learning prompts for learners, especially the performance phase (i.e., in the middle of the video).

Besides the self-regulated learning prompts, participants also mentioned other support they believed would benefit them in learning from the video. These support mechanisms included notetaking, quizzes, captions, and workbook/worksheet to fill in while watching the video. Incorporating these strategies in videos could also possibly enhance the learning experience by promoting self-regulated learning and engagement. Future research, however, is needed to further examine the effectiveness of these strategies.

Limitations and Future Research

Despite the contributions of the current study, certain limitations of the present study should be noted.

First, the current study adopted the measure of self-report and process-oriented measures of self-regulated learning during video-watching. A concurrent think-aloud protocol (Tuysuzoglu & Greene, 2015; Ericsson, 2006) could be adopted to gather participants' verbal accounts of self-regulated learning while watching the video. Future research could use this protocol and analyze the responses to identify the themes around self-regulated learning processes and strategies in a more nuanced manner.

Second, a larger sample size could be adopted for future research to enhance the generalizability of the findings reported in the current study. Additionally, further research is needed to determine if and how the current findings may extend to other student populations, for example, K-12 students.

Third, the current study was conducted during a short period of time and focused on one single video on the human respiratory system. We recommend future research conduct the study in a more ecologically valid learning context for a longer period of time, to see the long-term effect of providing self-regulated learning prompts on students' self-regulated learning behavior and learning outcome.

Finally, the current study only adopted the pausing and rewinding behavior to objectively measure learners' self-regulatory processes while watching a video. A more comprehensive use of log data may provide a way to trace and detect students' self-regulated learning processes in an online learning setting and provide adaptive instruction. For example, Schumacher and Ifenthaler (2021) suggested future research investigate adaptive prompts with the support of learning analytics. Along the same line, the future design of online video is recommended to capitalize on tracing learners' self-regulated learning processes and provide adaptive instructional support to actively engage learners in the video-watching process.

In future research, it is also crucial to explore the optimal timing, frequency, and various types of self-regulated learning prompts. Additionally, future research should investigate how these factors interact within diverse learning contexts and among different learner groups. Through detailed analysis of these factors, we can gain deeper insights into effective self-regulated learning strategies and design tailored interventions to meet the diverse needs of learners in different educational contexts.

Declarations

Conflict of Interest The authors declare no competing interests.

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