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# MIND MAPPING AND REAL-TIME COMMENTING TO SUPPORT UNIVERSITY STUDENTS' SELF-REGULATED LEARNING IN VIDEO CREATION

**Abstract.** Video creation offers students opportunities for active and authentic learning while enabling them to acquire knowledge and 21st-century skills across various disciplines. In the AI-driven era of higher education, video creation could become one of the most effective pedagogical approaches. Self-regulated learning (SRL) is a key higher-order skill for 21st-century learners, that enables them to adapt as lifelong learners in dynamic environments. Students' video creation is an active learning activity that requires SRL, as students need to manage the processes of goal setting, planning, and managing their projects. However, these SRL processes do not occur naturally or easily. Therefore, we need to intentionally design learning environments and teaching practices to enhance students' SRL. Two potential scaffolding approaches that can support students' SRL in the video creation learning process are mind mapping and real-time commenting. This study investigated the effects of these two approaches on seven key aspects of SRL in video creation activities: goal setting, planning, self-monitoring, evaluation, reflection, self-efficacy, and effort. We carried out an eight-week intervention study involving 140 Chinese university students and employed a 2 × 2 between-subjects factorial design with four intervention groups. Our analysis revealed that: (i) mind mapping significantly enhanced five aspects of students' SRL: goal setting, planning, self-monitoring, reflection, and self-efficacy; (ii) real-time commenting significantly improved two aspects of students' SRL: evaluation and reflection; and (iii) neither mind mapping nor real-time commenting significantly enhanced students' effort. The results highlight the effectiveness of mind mapping and real-time commenting in supporting different phases of students' SRL in video-based learning, with practical implications that include the potential use of generative AI tools in multimedia learning contexts to enrich instructional practices.

**Keywords:** student-created videos; mind mapping; real-time commenting; multimodal learning; self-regulated learning

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## 1. INTRODUCTION

**The problem statement**. Globalization and technological developments have transformed workplace practices [1]. Newly graduated students are expected to possess new skills and exhibit their value beyond their degree. Instructional design that mainly focuses on transmitting subject knowledge does not adequately equip university students for their future careers. Students should complete learning tasks that can develop the essential skills related to their careers and reflect professional practice. Video creation offers opportunities for students to participate in active and authentic learning experiences while fostering knowledge and 21st-century skills across various subjects [2]. The potential for student video creation has encouraged educators to explore its integration into pedagogy, using it as a strategy for teaching and learning within disciplines [2], [3].

During video creation, students need to take the initiative and develop strategies to set goals, plan, produce, edit, and present their video products [4]. This proactive learning process requires self-regulated learning (SRL) [5]. SRL is the self-directive process through which learners transfer their mental abilities into academic skills [6]. This directive process is strongly associated with students' motivations to learn and engage in learning activities. Such processes may include strategies like setting goals, planning, self-monitoring, reflecting, and making strategic adjustments to ensure progress towards achieving their learning objectives. However, for many students, these processes do not occur naturally or easily. Therefore, the learning environment and teaching practices need to be intentionally designed to support students' SRL during video creation.

**Analysis of recent studies and publications.** In learning with video creation, mind mapping and real-time commenting are two student-centered approaches that have the potential to enhance students' SRL. For example, mind mapping can help students identify and set goals, plan learning tasks, and monitor whether they are progressing according to their goals and plan [7]. Real-time commenting anchors feedback to specific moments during video playback. This allows students to pinpoint strengths and weaknesses in particular aspects of performance, thereby supporting their evaluation of and reflection on the learning process [8]. Mind mapping and real-time commenting could encourage students to regulate their learning actively and reflectively.

Nevertheless, the integration of these approaches into student video creation has yet to reach its full potential; content, technologies, and pedagogies should be carefully integrated into the instructional design [9], [10]. Further studies are required to investigate strategies and methods for improving their effectiveness. Literature shows that technological scaffolding can help students better manage their learning process, enhancing their self-regulated learning skills in computer-based learning environments [11]. However, most existing interventions are focused on the performance phase in higher education [12], and there is a lack of detail on how teaching and learning practices have been used to integrate these technologies into the learning process to support students' learning [13].

Existing research indicates that both mind mapping and real-time commenting can enhance certain aspects of student SRL, but the evidence is not yet systematic and remains mixed. Prior studies suggest that mind mapping supports processes such as goal setting and planning, whereas other studies caution that real-time commenting may disrupt learning by diverting attention from materials and leading to cognitive overload [14]. These inconsistencies highlight the need to further examine how the two strategies can be effectively integrated into student video creation to foster SRL and support meaningful learning.

**The research goal.** This study aims to examine the effects of mind mapping and real-time commenting on university students' SRL in video creation activities. Specifically, we examined (i) whether mind mapping and real-time commenting affect students' SRL, and (ii)

how students perceive the use of mind mapping and real-time commenting in relation to their SRL during the video creation process. To achieve this research goal, we adopted a 2 × 2 between-subjects factorial design with two factors: mind mapping (with vs. without) and real-time commenting (with vs. without). Accordingly, this study addresses the following research questions:

RQ1: How do mind mapping and real-time commenting affect students' SRL?

RQ2: How do students perceive the use of mind mapping and real-time commenting in relation to their SRL during the video creation process?

## 2. THETHEORETICAL BACKGROUNDS

This section presents the key concepts and approaches of the study, including student video creation in higher education, the theory of SRL, and the potential roles of mind mapping and real-time commenting in supporting SRL.

### 2.1. Student video creation in higher education

Student-created video activity is grounded in experiential learning, engaging students in solving problems related to both the subject matter and the creation of the multimedia product. Students apply concepts taught in the classroom to real-world practice and demonstrate them through their productions [3]. They need to analyze a subject-related topic [15], present solutions to real-world problems, and reflect on their learning experiences [16], [17]. In higher education, student-created videos are used across various disciplines to facilitate learning and demonstrate understanding. These videos can take the form of news stories, documentaries, advertisements, laboratory reports, or research on specific subjects [4]. Video creation activities can enhance cognitive outcomes, such as conceptual understanding [18], develop skills like creativity and collaboration [19], and promote metacognitive outcomes, such as self-reflection [17].

When creating videos, student learning activities involve researching, planning storyboards, writing scripts, practicing, filming, editing, and other post-production tasks. To succeed in these activities, students must take responsibility for their own learning. In other words, they need to set goals, plan, monitor, and reflect on their progress, while staying motivated throughout the process. In other words, they should be able to manage their learning effectively and have the capability to engage in complex practices. However, for many students, this can be difficult. For example, students may face challenges such as lack of time for creation and reflection, and difficulties with task planning and allocating resources [10]. Therefore, the learning environment and teaching practices in the student video creation project must be intentionally designed to support students' SRL in order to optimize its effectiveness.

### 2.2. Self-regulated learning (SRL)

SRL refers to an intentional and adaptive process of one's learning that allows learners to plan, adapt, and monitor their thoughts, emotions, and behaviors according to the requirements of a learning situation or task [6], and is key to effective learning [20]. Several studies have highlighted significant differences in university students' SRL skills [21],[22], and these skills also vary across different learning contexts [23]. According to Zimmerman [24], self-regulated learning occurs in three sequential phases: forethought (before learning efforts), performance control (during learning efforts), and self-reflection (after learning).

During the forethought phase, learners analyze learning tasks, set goals, and develop plans to achieve those goals. Additionally, self-motivational beliefs, such as self-efficacy,

interest, and personal views on the value of learning, are also considered part of this phase. During the performance phase, learners use a range of methods, monitor, and observe their learning. Lastly, in the self-reflection phase, learners evaluate and reflect on their performance. These phases are considered interdependent; changes in the forethought phase can affect performance control, which, in turn, may influence the self-reflection phase.

When working on student-centered learning tasks, students may encounter self-regulation challenges. They need to make decisions and manage their work over a number of phases. Without proper guidance or support, they may experience lower levels of self-regulation during the learning process [21]. Therefore, thoughtful design and support are needed to support students in engaging in SRL process.

### 2.3. Mind mapping and real-time commenting supporting SRL in the video creation process

The video creation process involves a range of activities, from researching materials and generating visualizations to interpreting potential solutions [4]. These learning activities require students to set goals, plan, organize, and manage resources. Instructional designs that support SRL can help students better navigate the learning process, ensuring the successful completion of the activities. Two potential scaffolding approaches that can support students' SRL in the video creation learning process are mind mapping and real-time commenting. They can effectively facilitate students' SRL processes.

Mind mapping is a visual tool for managing a range of educational tasks, such as organizing information, generating ideas, brainstorming, and facilitating meta-learning [25, 26]. A mind map visually connects various levels of ideas through graphics, images, and keywords. This structure reflects both the macro-level framework of the central theme and the intricate micro-relationships between different levels of ideas [26]. Mind mapping can improve several aspects of SRL. For example, it can promote students' goal-setting by helping them visualize and structure concepts and the relationships between them. This makes it easier for students to clarify the learning content and set specific, clear learning goals [7]. It also helps students organize information and break down learning tasks into manageable levels, thereby promoting more effective planning. In addition, mind mapping facilitates students' self-monitoring of their learning processes related to the subject content through an organized visual representation. Moreover, it can build a framework for reflection, helping students systematically review and reflect on what they have learned [27]. When students better understand complex concepts, they feel more confident in completing tasks, which enhances their self-efficacy in learning.

Real-time commenting is a feature of video websites that displays comments scrolling over the screen during video playback, allowing viewers to watch the video and read the comments simultaneously [28], [29]. In an educational context, its core pedagogical affordance lies in providing time-synchronized peer feedback: comments are anchored to specific moments in the video, enabling viewers to deliver and receive feedback that is directly tied to particular scenes, narration segments, or visual choices. This time-anchored mechanism distinguishes real-time commenting from a synchronous discussion boards, where feedback is typically detached from specific content moments. Although over lay-stylereal-time commenting originated on particular videoplatforms (e.g., Bilibili, Niconico), functionally equivalent time stamped commenting features are available in video annotation tools used in educational settings (e.g., Panopto). In this study, we focus on the underlying pedagogical mechanism – time-synchronized peer feedback during video review. Existing research suggests that real-time commenting has the potential to promote SRL in video-based learning environments, particularly for the self-reflection phase. For example, Gong and Yan [8] found that

implementing real-time commenting feedback in English oral classes can encourage students' self-reflection on their learning progressions. This real-time interactive feedback can facilitate students' reflective learning experiences, helping them develop a deeper understanding and reflection on their oral performance. However, some findings indicate that real-time commenting may interfere with students' self-learning process, as the comments can divert their attention from the learning materials and lead to cognitive overload [14]. Therefore, the overall impact of real-time commenting on student learning remains inconclusive, highlighting the need for further investigation.

## 3. RESEARCH METHODS

### 3.1. Participants

The intervention was conducted at a private university in Shanghai, China. The participants were 140 second- and third-year students from four classes at the School of Management who were enrolled in a Human Resource Management (HRM)course. All participants had previously completed Fundamentals of Management courses to ensure they possessed similar basic knowledge.

The four intervention groups were: video creation (VC, n = 35), video creation with mind mapping (VC-MM, n = 38), video creation with real-time commenting (VC-RC, n = 29), and video creation with mind mapping and real-time commenting (VC-MM-RC, n = 38).The participants, aged 19 to 24, comprised 37 males (26.43%) and 103 females (73.57%), reflecting the typical gender distribution in business and management programs at this university, which generally have a higher proportion of female students. This design adhered to ethical guidelines and aimed to preserve authentic learning environments without interfering with the students' educational experience.

### 3.2. Research design and procedure

This study employed a mixed-method sequential explanatory design. In the first phase, the quantitative approach provided objective statistical findings from the intervention (RQ1). In the second phase, semi-structured interviews were conducted to analyze participants' subjective responses and to explain the phenomena observed in the quantitative data (RQ2). The interviews aimed to develop a qualitative understanding of students' use of SRL strategies and the underlying reasons for their strategy choices, thereby complementing the quantitative results and contributing to a more comprehensive picture of students' SRL strategy use.

The course spanned eight weeks, with four hours of instruction each week. Its objective was to introduce the concepts, scope, practices, and research topics of HRM.For the main assignment, students applied HRM concepts to real-world scenarios – such as recruitment, employee development, and performance management – by creating a digital video that illustrated organizational challenges and proposed solutions.

We obtained ethical approval from the university and received consent from all participants. Prior to the intervention, the instructor introduced the procedure to all participants and administered the pre-questionnaire. During the intervention, students worked in groups of four or five. In the first lesson, the instructor explained the video creation project and its expectations. The VC-MM group was introduced to mind mapping, the VC-RC group to danmaku (real-time commenting), and the VC-MM-RC group to both tools.

Figure 1 illustrates the use of the ProcessOn (https://www.processon.com/) for a mindmap created by a student group. ProcessOn was chosen as the tool for mindmapping because it is web-based, accessible via smartphones and tablets without software installation,

and provides a Chinese-language interface, which makes it appropriate for Chinese students. Figure 2 shows a screenshot of students' real-time comments on Bilibili (https://www.bilibili.com/). Bilibiliis a widely used video-sharing platform in China that allows users to post real-time comments, known as danmaku – a Japanese term meaning "barrage" or "bullet curtain" in English. This platform enabled students to comment on their videowork, and participants in the VC-RC and VC-MM-RC groups uploaded their videos to Bilibili before the final presentation.

From Weeks 1 to 3, all students studied HRM principles and concepts to build a foundational knowledge base for the video project. From Weeks 4 to 8, the groups followed different approaches: (i) the VC group created videos demonstrating a problem-solving scenario and its solutions as their course deliverable, following a typical video creation process (i.e., theme identification, planning, production, editing, and presentation); (ii) the VC-MM group created mind maps before video production and then completed their video creation; (iii) the VC-RC group completed their video creation and then exchanged real-time comments with other groups during the presentation phase; and (iv) the VC-MM-RC group engaged in both activities, creating mind maps and exchanging real-time comments, in addition to completing the video creation process. Throughout the learning process, the instructor acted as a facilitator, and all groups went through the three phases of SRL, applying strategies such as goal setting, planning, monitoring, evaluating, and reflecting on their progress, although the VC group did not receive any additional tool support.

All the students completed a post-questionnaire in the last lesson. Moreover, twelve students (six males and six females) from the video creation with mind mapping, video creation with real-time commenting, and video creation with mind mapping and real-time commenting groups were invited to participate in interviews. The interview lasted for 30 - 40 min for each interviewee and aimed to gather views on the intervention activities and complement the quantitative data.

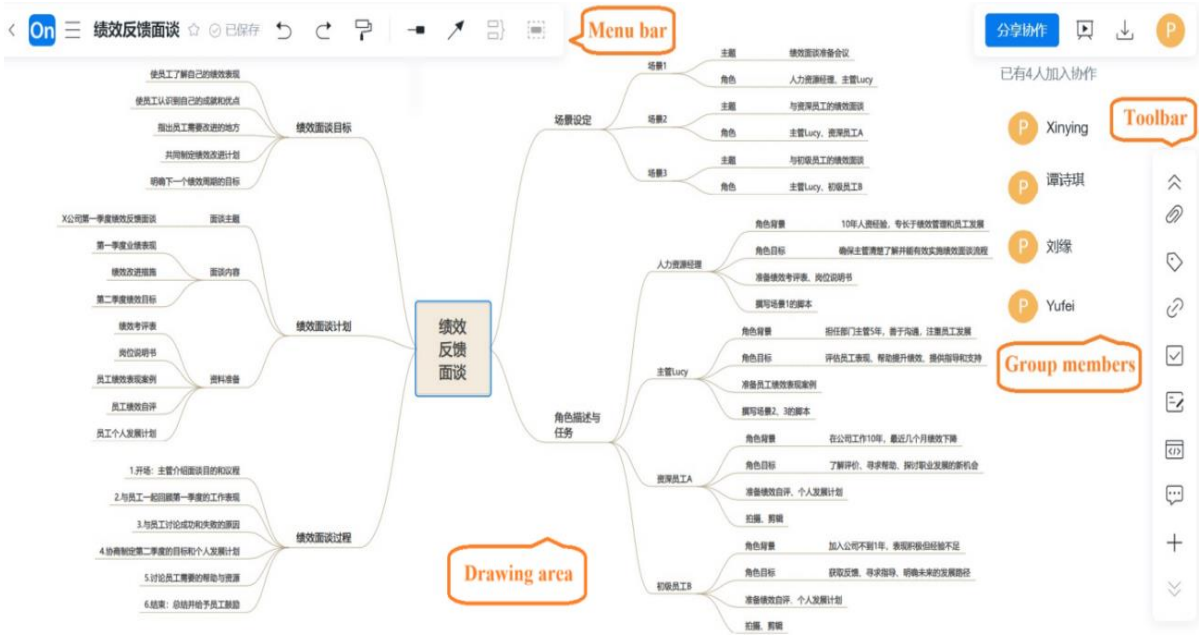


*Figure 1. Mind map generated by the student group on the ProcessOn platform*

*Figure 2. Screenshot students' danmaku comments*

### 3.3. Measures

Pre- and post-questionnaires were administered to gather data to answer the first research question. Both questionnaires measured demographic data and students' SRL. Seven aspects of SRL were assessed: goal setting, planning, self-monitoring, evaluation, reflection, self-efficacy, and effort. Each measure was assessed on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). All items were adapted from the previously published instruments with acceptable original reliability and validity.

Goal setting was measured using four items adapted from the Online Self-Regulated Learning Questionnaire [30]. The items were "I set standards for my tasks in this course," "I set short-term goals (daily or weekly) and long-term goals (for the project) in this course," "I keep a high standard for my tasks in this course," "I set goals to help me manage my time for this course."

Planning, self-monitoring, evaluation, reflection, self-efficacy, and effort were each measured using four items adapted from the Self-Regulation of Learning Self-Report Scale [31]. The items for planning were "I think through the steps of a plan I have to follow for tasks in this course," "I ask myself questions about what a problem requires me to do to solve it, before I do it," "I develop a plan for the solution of a problem in this course," "I clearly plan my course of action to complete tasks for this course." The items for self-monitoring were "I check how well I am doing when I solve a task for this course," I check my work for this course while doing it," "I check my accuracy as I progress through a task for this course," "I check the correctness of my work for this course." The items for evaluation were "I look back and check if the work I did for this course was correct," "I look back to see if I followed the correct procedures for tasks in this course," "I look back at the problem to see if my solution makes sense," "I rethink the work I have already done for this course." The items for reflection were "I reappraise my experiences so I can learn from them," "I try to think about my strengths and weaknesses," "I think about my actions to see whether I can improve them," "I try to think about how I can do things better next time." The items for self-efficacy were "I am confident that I could deal efficiently with unexpected events," "If I am in a bind, I can usually think of something to do," "I always manage to solve difficult problems if I try hard enough," "I remain

calm when facing difficulties, because I know many ways to cope with them." The items for effort were "I keep working even on difficult tasks in this course," "I put forth my best effort when performing tasks in this course," "If I'm not really good at a task I can compensate for this by working hard," "I am willing to do extra work on tasks in order to learn more."

Furthermore, all scales in this study demonstrated acceptable reliability, with Cronbach's alpha (CA) values ranging from 0.75 to 0.85 (Table 1).

*Table 1*

**Scale characteristics**

| Scales (Number of items) | CA in pre-questionnaire | CA in post-questionnaire |
|---|---|---|
| Goal setting (4) | 0.78 | 0.82 |
| Planning (4) | 0.80 | 0.85 |
| Self-monitoring (4) | 0.76 | 0.80 |
| Evaluation (4) | 0.76 | 0.83 |
| Reflection (4) | 0.81 | 0.84 |
| Self-efficacy (4) | 0.77 | 0.83 |
| Effort (4) | 0.75 | 0.80 |

### 3.4. Analytic approach

To answer RQ1, 2 × 2 univariate analyses of covariance (ANCOVAs) [(mind mapping: with vs. without mind mapping) × (real-time commenting: with vs. without real-time commenting)] were performed to compare seven aspects of SRL between groups, with pre-questionnaire scores as covariates.

To answer RQ2, the interview data were transcribed and translated into English. We used self-regulated learning as the framework to explore students' experiences throughout the learning process, their use of SRL strategies, and how mind mapping and real-time commenting facilitate the use of these strategies. The data were coded and validated by two independent coders. The inter-rater reliability is 82%. They both agree with the final results of the data analysis.

## 4. THE RESULTS AND DISCUSSION

### 4.1. Results

#### *4.1.1. Descriptive statistics*

Table 2 presents the descriptive statistics of all measures across the four groups in both questionnaires. The skewness values ranged from -0.97 to 0.81, and the kurtosis values ranged from -0.98 to 0.99, suggesting sufficiently normal distributions.

ANOVA indicated there were no significant differences in the pre-questionnaire scores for goal setting, $F$ (3, 136) = 0.18, $p$ = 0.91; planning, $F$ (3, 136) = 0.45, $p$ = 0.72; self-monitoring, $F$ (3, 136) = 0.56, $p$ = 0.64; evaluation, $F$ (3, 136) = 0.58, $p$ = 0.63; reflection, $F$ (3, 136) = 0.20, $p$ = 0.89; self-efficacy, $F$ (3, 136) = 0.54, $p$ = 0.66; and effort, $F$ (3, 136) = 0.36, $p$ = 0.78. These scores showed that the four groups perceived the seven aspects of SRL in a similar manner before the intervention.

*Table 2*

**Descriptive statistics and paired t-test for pre- and post-questionnaires**

| Group | Variables | Pre-questionnaire | | | Post-questionnaire | | | t |
|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | | Mean | SD | | |
| VC (N = 35) | Goal setting | 3.41 | 0.70 | | 3.75 | 0.58 | | -3.56** |
| | Planning | 3.47 | 0.73 | | 3.72 | 0.61 | | -1.85 |
| | Self-monitoring | 3.44 | 0.51 | | 3.67 | 0.57 | | -2.47* |
| | Evaluation | 3.42 | 0.52 | | 3.69 | 0.65 | | -2.01 |
| | Reflection | 3.38 | 0.62 | | 3.64 | 0.64 | | -2.11* |
| | Self-efficacy | 3.53 | 0.56 | | 3.66 | 0.66 | | -1.11 |
| | Effort | 3.51 | 0.46 | | 3.74 | 0.61 | | -2.13* |
| VC-MM (N = 38) | Goal setting | 3.48 | 0.56 | | 4.12 | 0.60 | | -4.97*** |
| | Planning | 3.57 | 0.61 | | 4.26 | 0.58 | | -5.08*** |
| | Self-monitoring | 3.40 | 0.55 | | 4.02 | 0.58 | | -4.49*** |
| | Evaluation | 3.38 | 0.57 | | 3.86 | 0.64 | | -3.23** |
| | Reflection | 3.49 | 0.57 | | 3.88 | 0.60 | | -2.80** |
| | Self-efficacy | 3.36 | 0.59 | | 3.97 | 0.65 | | -4.43*** |
| | Effort | 3.41 | 0.55 | | 3.86 | 0.67 | | -3.00** |
| VC-RC (N = 29) | Goal setting | 3.45 | 0.60 | | 3.75 | 0.62 | | -2.12* |
| | Planning | 3.59 | 0.56 | | 3.79 | 0.56 | | -1.77 |
| | Self-monitoring | 3.55 | 0.57 | | 3.81 | 0.60 | | -1.92 |
| | Evaluation | 3.47 | 0.63 | | 4.06 | 0.64 | | -3.53** |
| | Reflection | 3.42 | 0.62 | | 3.95 | 0.60 | | -3.93*** |
| | Self-efficacy | 3.44 | 0.67 | | 3.75 | 0.64 | | -1.87 |
| | Effort | 3.53 | 0.60 | | 3.78 | 0.60 | | -2.42* |
| VC-MM-RC (N = 38) | Goal setting | 3.38 | 0.65 | | 4.17 | 0.64 | | -6.16*** |
| | Planning | 3.45 | 0.55 | | 4.22 | 0.55 | | -6.10*** |
| | Self-monitoring | 3.52 | 0.57 | | 4.10 | 0.59 | | -5.01*** |
| | Evaluation | 3.55 | 0.57 | | 4.12 | 0.52 | | -4.73*** |
| | Reflection | 3.42 | 0.60 | | 4.26 | 0.55 | | -6.92*** |
| | Self-efficacy | 3.50 | 0.63 | | 3.95 | 0.54 | | -4.06*** |
| | Effort | 3.48 | 0.51 | | 3.91 | 0.55 | | -4.47*** |

#### *4.1.2. The influence of mind mapping and real-time commenting on SRL (RQ1)*

Table 3 presents a summary of the main and interaction effects. For goal setting, the assumption of homogeneity was validated, $F = 0.98$, $p = 0.41$. ANCOVA revealed a significant main effect of the mind mapping intervention, $F(1, 135) = 15.67$, $p < 0.001$, partial $\eta^2 = 0.10$, suggesting that the group with mind mapping (M = 4.14, SD = 0.62) performed significantly better than the group without mind mapping (M = 3.75, SD = 0.59). There was no significant main effect of the real-time commenting intervention, $F(1, 135) = 0.12$, $p = 0.73$, partial $\eta^2 = 0.001$. There was no significant interaction effect between mind mapping and real-time commenting, $F(1, 135) = 0.22$, $p = 0.64$, partial $\eta^2 = 0.002$.

For planning, Levene's test was performed, and homogeneity was confirmed, $F = 0.57$, $p = 0.64$. ANCOVA showed a significant main effect of the mind mapping intervention, $F(1, 135) = 25.56$, $p < 0.001$, partial $\eta^2 = 0.16$, indicating that the group with mind mapping (M = 4.24, SD = 0.56) performed better than the group without mind mapping (M = 3.75, SD = 0.58). There was no main effect of the real-time commenting intervention, $F(1, 135) = 0.02$, $p = 0.90$, partial $\eta^2 = 0.0001$; nor was there an interaction effect between mind mapping and real-time commenting, $F(1, 135) = 0.17$, $p = 0.68$, partial $\eta^2 = 0.001$.

For self-monitoring, homogeneity existed with $F = 0.56$, $p = 0.64$. ANCOVA indicated a significant main effect of the mind mapping intervention, $F(1, 135) = 10.94$, $p = 0.001$, partial $\eta^2 = 0.075$, indicating that the group with mind mapping (M = 4.06, SD = 0.59) outperformed the group without mind mapping (M = 3.73, SD = 0.58). There was no main effect of the real-time commenting intervention, $F(1, 135) = 0.74$, $p = 0.39$, partial $\eta^2 = 0.005$. No significant interaction effect was found, $F(1, 135) = 0.10$, $p = 0.76$, partial $\eta^2 = 0.001$.

For evaluation, homogeneity was proved by Levene's test, $F = 0.72$, $p = 0.54$. ANCOVA indicated a significant main effect of the real-time commenting intervention, $F(1, 135) = 8.96$, $p = 0.003$, partial $\eta^2 = 0.06$, indicating that the group with real-time commenting (M = 4.09, SD = 0.57) scored significantly higher than the group without real-time commenting (M = 3.78, SD = 0.64). There was no main effect of the mind mapping intervention, $F(1, 135) = 1.19$, $p = 0.28$, partial $\eta^2 = 0.009$. There was no significant interaction effect between mind mapping and real-time commenting, $F(1, 135) = 0.27$, $p = 0.60$, partial $\eta^2 = 0.002$.

For reflection, Levene's test confirmed homogeneity, $F = 0.28$, $p = 0.84$. ANCOVA demonstrated a significant main effect of the real-time commenting intervention, $F(1, 135) = 12.08$, $p < 0.001$, partial $\eta^2 = 0.08$, indicating that the group with real-time commenting (M = 4.13, SD = 0.59) outperformed the group without real-time commenting (M = 3.76, SD = 0.62). There was also a significant main effect of the mind mapping intervention, $F(1, 135) = 6.95$, $p = 0.009$, partial $\eta^2 = 0.05$, indicating that the group with mind mapping (M = 4.07, SD = 0.60) achieved better outcomes than the group without mind mapping (M = 3.78, SD = 0.64). No significant interaction effect was found, $F(1, 135) = 0.25$, $p = 0.62$, partial $\eta^2 = 0.002$.

For self-efficacy, the assumption of homogeneity was validated, with $F = 0.74$, $p = 0.53$. ANCOVA showed a significant main effect of the mind mapping intervention, $F(1, 135) = 6.75$, $p = 0.01$, partial $\eta^2 = 0.05$, indicating that the group with mind mapping (M = 3.96, SD = 0.59) outperformed the group without mind mapping (M = 3.70, SD = 0.65). There was no main effect of the real-time commenting intervention, $F(1, 135) = 0.09$, $p = 0.76$, partial $\eta^2 = 0.001$; nor was there an interaction effect between mind mapping and real-time commenting, $F(1, 135) = 0.58$, $p = 0.45$, partial $\eta^2 = 0.004$.

For effort, the results of the paired t-test in table 3 indicated that the four groups exhibited significant improvements in effort after video creation: the video creation group ($t = -2.13$, $p = 0.04$), the video creation with mind mapping group ($t = -3.00$, $p < 0.01$), the video creation with real-time commenting group ($t = -2.42$, $p = 0.02$), and the video creation with mind mapping and real-time commenting group ($t = -4.47$, $p < 0.001$). Then ANCOVA was performed to assess the impacts of mind mapping and real-time commenting on effort. The assumption of equal variances was met with Levene's test, $F = 1.49$, $p = 0.22$. ANCOVA showed no significant main effect of the mind mapping intervention, $F(1, 135) = 1.95$, $p = 0.17$, partial $\eta^2 = 0.01$; no significant main effect of the real-time commenting intervention, $F(1, 135) = 0.10$, $p = 0.75$, partial $\eta^2 = 0.001$; and no significant interaction effect of mind mapping by real-time commenting, $F(1, 135) = 0.004$, $p = 0.95$, partial $\eta^2 = 0.00003$). These results indicated that neither the mind mapping nor real-time commenting interventions significantly increased students' effort.

*Table 3*

**Summary of the main and interaction effects**

| Variable | Main effect of mind mapping | Main effect of real-time commenting | Interaction effect |
|---|---|---|---|
| Goal setting | Yes | No | No |
| Planning | Yes | No | No |
| Self-monitoring | Yes | No | No |
| Evaluation | No | Yes | No |
| Reflection | Yes | Yes | No |
| Self-efficacy | Yes | No | No |
| Effort | No | No | No |

### *4.1.3. The use of mind mapping and real-time commenting in support of SRL (RQ2)*

*Goal setting*

The students expressed that through mind mapping, they were able to outline and visualize the needs of the video project, and organize and clarify the goals for each phase. This visual structure helped them understand the content and the connections between concepts and stages, enabling them to set clear objectives for each phase. This tool helped them manage the project's complexity by breaking it down into clear, achievable goals, ensuring a goal-oriented and manageable process.

The following excerpts show how the tool helps them with goal setting.

Goal setting and orientation: "I knew what needed to be done and set goals for each stage." (Student 1, VC-MM group)

Task analysis for the goals setting: "I was well aware of the tasks as they were laid out on the map." (Student 2, VC-MM group)

Goal orientation: "After listing the goals, I had a clearer sense of the direction moving forward." (Student 10, VC-MM-RC group)

*Strategic planning*

The interview data showed that students used mind maps to lay out the content related to the theme and organize the relationships between different elements. This process facilitated students' planning by helping them structure their work logically and ensure smooth transitions between stages. For example, when designing the recruitment scenes, students mapped out the key points of each scene and arranged them in a reasonable order to ensure a coherent final product.

In addition to breaking down tasks, the mind maps also supported task allocation, helping students better understand the project structure and clarify their responsibilities. This clarity contributed to better planning, allowing each student to focus on their role and ensuring smoother progress throughout the project.

The following excerpts show how the tool helps them with strategic planning.

Task analysis: "I identified the key points of the recruitment scenes and organized them." (Student 10, VC-MM-RC group)

Task interest and value: “Through mapping, I identified the relationships between tasks and planned out the required actions.” (Student 3, VC-MM group)

Task analysis: “I focused on my role and knew what needed to be done to complete it.” (Student 2, VC-MM group)

*Self-monitoring*

Students reported that the visual structure of mind maps helped them check if their work aligned with their goals. This process provided a clear framework for monitoring progress and ensuring consistency with objectives at each stage. Additionally, the use of colors and symbols helped students prioritize tasks and make necessary adjustments.

The following excerpts show how the tool helps them with self-monitoring.

Self-recording: “I referred to the mind map to check if the progress matched the initial goals.” (Student 1, VC-MM group)

Self-recording: “I checked my work and thought about ways to make it better.” (Student 11, VC-MM-RC group)

Self-recording: “Using different colors and symbols helped me identify tasks and think about necessary adjustments.” (Student 3, VC-MM group)

*Self-evaluation and self-reflection*

The interview data showed that real-time commenting facilitated students’ the exchange of feedback among students on their video work. This interaction, centered on the theme, assisted students in evaluating their performance, particularly in areas such as creativity, expression, and skill application. Students were able to receive peer feedback from multiple perspectives. In commenting on others’ work, they could judge their own performance. For instance, after seeing the impressive work of another group, one student realized that her rushed editing had led to a relatively flat presentation.

Moreover, the interview revealed that mind mapping and real-time commenting activities helped students reflect on the theme and their learning process. Through mind mapping, students built a structured framework for the theme, relating knowledge to their practice and facilitating the retrospection of their video creation experience. Additionally, by collaborating with group members in the mapping, students could draw on others’ ideas and perspectives. This co-construction of knowledge and exchange of thoughts supported their reflection. Students who participated in real-time commenting expressed that watching and commenting in real time facilitated their reflection on their performance and learning experience. Through exchanging feedback, they could gain insights into the details of their work and the reasoning behind the decisions. Furthermore, because the commenting occurred synchronously with the video, students were able to reflect on specific moments as they watched. This form of reflection was situational, allowing students to respond to particular moments in the video while enhancing their understanding.

The following excerpts show how the tool helps them with self-evaluation and self-reflection.

Peer comments and review:

“I feel like our video had a clear story, but the presentation could have been more creative.” (Student 7, VC-RC group)

“After reviewing other groups’ work, I realized my editing skills need improvement.” (Student 8, VC-RC group)

“I think our decision on task allocation was correct and helped us deliver a well-structured video.” (Student 5, VC-RC group)

"I reviewed the project process and thought about which parts could be improved." (Student 4, VC-MM group)

Self-satisfaction (i.e., affective and defensive):

"Watching and commenting helped me recognize my strengths and weaknesses, and think about how I could improve next time." (Student 8, VC-RC group)

"When I watched that scene, I realized I wasn't confident in my performance. Next time, I hope to perform better." (Student 11, VC-MM-RC group)

*Self-efficacy*

Students expressed that engaging in mind mapping made them feel more confident about completing the video production task. Mind mapping scaffolded their learning, helped them understand subject-related knowledge, and enhanced their sense of control over learning activities. Additionally, during co-mapping, students could see their own contributions, fostering a positive perception of their learning abilities. This recognition boosted their confidence and self-efficacy in completing learning tasks.

The following excerpts show how the tool helps them with self-efficacy.

Task interest and value: "It was really helpful for us to organize the content and write the scripts. It made me feel more confident about doing a good job on the task." (Student 2, VC-MM group)

Task interest and value: "After clarifying each step, I felt more prepared for the subsequent tasks." (Student 9, VC-MM-RCgroup)

Goal orientation: "I could see the overall picture. It made me more confident in completing task." (Student 10, VC-MM-RCgroup)

### 4.2. Discussion

This study designed an intervention to examine how mind mapping and real-time commenting influence students' SRL during the process of video creation. The findings provide three empirical implications, two theoretical contributions, and two practical suggestions for practitioners and instructional designers.

#### *4.2.1. Empirical implications*

First, the use of mind mapping significantly enhanced five aspects of students' SRL: goal setting, planning, self-efficacy, self-monitoring, and reflection (RQ1). Mind mapping promoted students' goal setting and planning in the initial phase of the project. Its visual structure and information organization features allowed students to break down ideas, goals, and sub-goals into branches, making goal setting more intuitive and helping them formulate action plans based on the goals and priorities they set [7], [32]. Additionally, since the mind mapping in this project was collaborative, students co-constructed knowledge with their peers, enriching their understanding and enabling them to recognize their own contributions. This process helped them develop a positive perception of their abilities, enhancing their sense of self-efficacy to complete learning tasks [33]. Moreover, mind mapping significantly improved students' self-monitoring, as its structured visual presentation made it easier for them to check their progress and ensure that their work aligned with their goals and plans [32]. Furthermore, mind mapping enhanced students' reflection by helping them develop a reflective framework related to the theme, enabling them to connect knowledge to practice and facilitating retrospection on their learning process [27].

Second, the use of real-time commenting significantly improved two aspects of students' SRL: evaluation and reflection (RQ1). This may be because real-time commenting provides opportunities for time-anchored comparison as well as diverse feedback. Since comments are

tied to specific moments in the video, students can pinpoint exactly which scene, narration, transition, or visual choice is being commented on, reducing the ambiguity often associated with general comments and making evaluation more focused. While watching and commenting on others' work, students could compare their own work with that of their classmates, enabling them to identify where they excelled and where they needed improvement. Moreover, diverse feedback from multiple classmates enriched students' understanding, enabling them to evaluate more comprehensively [8]. Beyond evaluation, peer comments may also prompt students to reconsider their thinking, strategies, and learning process, especially when they realize that others' understanding or feelings about their work differ from their own. Furthermore, student emotions have been shown to influence multimedia learning [34]. Real-time commenting can be accompanied by emotional reactions, and such emotional resonance with the themes and tasks may further foster deeper reflection from a socio-emotional perspective.

Third, while video creation project positively contributed to the development of students' effort, mind mapping and real-time commenting did not significantly improve effort (RQ1). Projects related to authentic problems can significantly enhance student effort [35], as students need to invest substantial effort in solving problems to complete the project and deliver a final product. Therefore, students who participated in the video creation project demonstrated increased effort. On the other hand, mind mapping and real-time commenting did not significantly enhance their effort. This may be because these tools, as cognitive and social interaction support, primarily assist with processes like planning, reflection, and cognitive regulation. However, as scaffolding tools, they may not be sufficiently challenging to elicit additional effort from students.

#### *4.2.2. Theoretical contributions*

First, the empirical results of this study advance our understanding of SRL in multimodal learning environments. Given that SRL is a complex, multi-component process, combining different interventions can be beneficial [12]. Although some studies have examined the impact of combined scaffolds [36], most have emphasized their overall effects rather than disentangling the unique contribution of each scaffold. Moreover, previous SRL research has tended to focus predominantly on the performance phase, leaving the preparatory and appraisal phases relatively underexplored [12]. The findings of this study indicate that mind mapping supports goal setting, planning, self-efficacy, self-monitoring, and reflection across all three SRL phases, with particularly strong effects in the preparatory and performance phases. In contrast, real-time commenting mainly influences evaluation and reflection during the appraisal phase. Integrating technological tools that align with different SRL phases can therefore enable higher education instructors to design more supportive learning environments and enhance the effectiveness of multimodal learning activities.

Second, this study contributes to the literature on reflective learning by highlighting the roles of cognitive tools and social interaction tools in promoting reflective learning. Reflection is both a cognitive and a socio-emotional process. Mind mapping serves as a cognitive tool that connects new and prior knowledge, helping students organize and understand content in meaningful ways [27], thereby fostering deep thinking and reflection.On the other hand, the theme-based social interactions and the emotional resonance accompanying real-time commenting prompt students to reflect on their learning processes. These two tools can promote deeper reflection on the learning process from cognitive and socio-emotional perspectives, respectively.

#### *4.2.3. Practical suggestions*

This study offers two practical recommendations for higher education instructional designers and teachers to enhance students' SRL in multimedia creation activities.

The first suggestion is to use mind mapping and real-time commenting for multimedia creation activities. Our results suggested that these two tools significantly improve students' SRL during video creation. Mind mapping could be useful in various multimedia creation activities, particularly for goal setting and planning at the beginning of a project. Real-time commenting is well suited to peer evaluation after students complete their work, enabling them to exchange feedback while reflecting on their own performance. This interactive process can facilitate students' self-evaluation and reflection toward the end of the project.For example, instructors can ask students to post comments on specific moments in peers' video work, helping them improve their understanding and performance.

The second suggestion is to integrate Sora, a generative AI tool for text-to-video creation, into the video production process. This tool enables the generation of personalized content tailored to students' needs, reducing reliance on teachers or technical assistance and allowing learners to engage in ways that accommodate their individual learning preferences. This suggestion is aligned with the current research and teaching trends that are related to AI in education. Incorporating AI-driven video production in classrooms can connect traditional teaching with contemporary technological practices, thereby equipping students with the competencies required to thrive in the digital age.

**Authors' personal contribution**

**Xueqing Fang** – conceptualization and design of the study; development of methodology; conducting formal data analysis and validation; writing the main parts of the manuscript, including the introduction, methodology, results, and conclusion sections; project administration, including organization of tasks and communication among authors; and review and editing of the manuscript.

**Ling Zhang** – project administration and coordination of research activities; conducting the literature review and synthesizing previous studies; validation of findings; and review and editing of the manuscript.

**Qi Xia** – participation in data analysis and interpretation of results; contribution to the discussion section; and review and editing of the manuscript.

**Xiaojing Weng** – providing pedagogical insights; support in clarifying the interpretation of findings; and review and editing of the manuscript.

**Thomas K.F. Chiu** – conceptualization of the study and supervision of the overall research process; validation of methodology and results; providing guidance throughout the research and writing process; and final review and editing of the manuscript.

## 5. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

This study examined the effects of mind mapping and real-time commenting on university students' SRL during video creation. The analysis revealed that: (i) mind mapping significantly enhanced goal setting, planning, self-monitoring, reflection, and self-efficacy; (ii) real-time commenting significantly improved evaluation and reflection; and (iii) neither mind mapping nor real-time commenting significantly enhanced students' effort. These results indicate that mind mapping primarily supports the preparatory and performance phases of SRL, while real-time commenting mainly contributes to the appraisal phase. These findings contribute to our understanding of how different scaffolds serve distinct functions across SRL phases and suggest that integrating mind mapping and real-time commenting into multimedia creation activities can effectively support students' SRL.

We acknowledge four limitations and propose directions for future research.

First, although it reflects authentic learning, the non-randomized assignment should not be overlooked. Additionally, the higher number of female students may introduce a bias

towards female perspectives. Future studies should aim for a more gender-balanced sample and utilize randomized control trials to enhance the validity of the findings.

Second, this study examined the short-term effects of mind mapping and real-time commenting on students' SRL; however, it remains unclear whether these benefits are sustained over time. As SRL is a continuous and dynamic process that evolves throughout students' educational journey, longitudinal studies are needed to evaluate whether the initial improvements are maintained or enhanced over extended periods, considering factors such as changes in academic performance, motivation, and adaptability to new learning environments.

Third, this study was conducted within the School of Management, which may limit the generalizability of the findings to other disciplines. The effectiveness of mind mapping and real-time commenting may vary across academic fields, as humanities and technical fields differ in their knowledge structures, learning approaches, and task requirements. Although these strategies may have potential value beyond the present context, their applicability to other disciplines requires further empirical validation. Future research should replicate this study across different disciplines, educational levels, and learning environments to examine whether the effects of mind mapping and real-time commenting remain consistent across contexts.

Finally, management issues and resource demands may affect the implementation of mind mapping and real-time commenting. Difficulties in coordinating participants and allocating adequate resources can compromise the efficiency and effectiveness of these tools. Future studies should examine how class size influences their implementation and effectiveness, and identify effective strategies for their implementation in diverse educational contexts.

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# ІНТЕЛЕКТ-КАРТИ ТА КОМЕНТУВАННЯ В РЕАЛЬНОМУ ЧАСІ ЯК ЗАСОБИ ПІДТРИМКИ САМОРЕГУЛЬОВАНОГО НАВЧАННЯ СТУДЕНТІВ ПІД ЧАС СТВОРЕННЯ ВІДЕО

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**Анотація**. Створення відео надає студентам можливості для активного та автентичного навчання, дозволяючи їм одночасно здобувати знання та навички XXI століття в різних дисциплінах. В епоху вищої освіти, що базується на штучному інтелекті, створення відео може стати одним із найефективніших педагогічних підходів. Саморегульоване навчання (СРН) є ключовою навичкою вищого рівня для учнів XXI століття, яка дозволяє їм адаптуватися як таким, що навчаються протягом усього життя, у динамічних умовах. Створення відео студентами є активною навчальною діяльністю, яка вимагає СРН, оскільки студенти повинні керувати процесами постановки цілей, планування та управління своїми проєктами. Однак ці процеси СРН не відбуваються природно чи легко. Тому нам потрібно цілеспрямовано розробляти навчальні середовища та методики викладання для покращення СРН студентів. Два потенційні підходи до створення опорних структур, які можуть підтримати СРН студентів у процесі навчання створенню відео, – це створення ментальних карт та коментування в режимі реального часу. У цьому дослідженні вивчався вплив цих двох підходів на сім ключових аспектів саморегулювання навчання в діяльності зі створення відео: постановка цілей, планування, самоконтроль, оцінка, рефлексія, самоефективність та зусилля. Ми провели восьмитижневе інтервенційне дослідження за участю 140 китайських студентів та застосували факторний дизайн 2 × 2 між суб'єктами з чотирма інтервенційними групами. Наш аналіз показав, що: (i) створення ментальних карт значно покращило п'ять аспектів саморегулювання навчання студентів: постановку цілей, планування, самоконтроль, рефлексію та самоефективність; (ii) коментування в режимі реального часу значно покращило два аспекти саморегулювання навчання студентів: оцінювання та рефлексію; та (iii) ані створення ментальних карт, ані коментування в режимі реального часу не покращили зусилля студентів. Результати підкреслюють ефективність використання ментальних карт та коментарів у реальному часі для підтримки різних етапів саморегульованого навчання студентів у процесі навчання на основі відео, що має практичне значення, зокрема щодо потенційного використання інструментів генеративного штучного інтелекту в мультимедійних контекстах навчання для збагачення педагогічних практик.

**Ключові слова:** відео, створені студентами; ментальні карти; коментарі в реальному часі; мультимодальне навчання; саморегульоване навчання

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