The influence of perceived control, perceived value, and enjoyment on self-regulated learning from text

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During self-regulated learning from text, learners often struggle to accurately judge their comprehension and hence to regulate their understanding effectively. These difficulties can limit learning gains. This highlights the need to identify factors that have an influence on comprehension, judgment accuracy, and regulation processes. This study aimed to investigate how reading enjoyment among 7th-grade students in intermediate secondary schools (German *Realschulen*, N = 217) influences their text comprehension, judgment accuracy, and regulation effectiveness. The experimental group received an intervention designed to increase enjoyment by enhancing perceived control and value, while the control group completed a control intervention. The results showed that the intervention successfully increased perceived control but not perceived value or enjoyment. An ANCOVA controlling for prior knowledge indicated significantly higher text comprehension in the experimental group than in the control group, $F(1, 214) = 4.64$, $p = 0.032$, $\eta^2 = 0.02$ (small effect). No significant group differences were found for judgment accuracy or regulation effectiveness. Based on these findings, teachers should support students' text comprehension by fostering their perceived control, for example, by providing motivational messages that emphasize effort and progress (e.g., "Everyone can master the learning content with effort, just as muscles grow with exercise"). Moreover, to draw valid conclusions about the causal influence of enjoyment on the accuracy of comprehension judgments and the effectiveness of regulation processes, replication of the study is required.

KEYWORDS

control-value, enjoyment, judgment accuracy, self-regulated learning, text comprehension

Introduction

Everyone knows the feeling of reading a text and enjoying it. However, it is an open question how enjoyment in reading influences self-regulated learning from texts. For successful self-regulated learning from text, in addition to comprehending the textual information, accurate judgments of one's text comprehension (i.e., accurate metacomprehension) and effective regulation are important. Specifically, more accurate judgments typically result in more effective regulation, for example, by rereading less well-understood contents. This leads to better comprehension (e.g., Barreyro et al., 2025; Dunlosky and Rawson, 2012; Thiede et al., 2003). Nevertheless, learners often have difficulties in judging their text comprehension accurately. In particular, they tend to overestimate their understanding when providing judgments prior to completing a comprehension test (i.e., predictions; e.g., Maki et al., 2005).

Learners make judgments about their comprehension based on available information—so-called cues (Griffin et al., 2009; see also Koriat, 1997). Despite the pervasive role of emotions in learning environments (e.g., Pekrun et al., 2007), little is known about their role as cues. Emotions experienced in relation to studying, such as during learning or after receiving a grade, are referred to as achievement emotions (e.g., Pekrun et al., 2007). Prinz-Weiß et al. (2022) were the first to investigate the role of achievement emotions as cues. Their findings indicated that achievement emotions are used as cues and influence metacomprehension accuracy. Specifically, stronger positive emotions were associated with greater overestimation, whereas stronger negative emotions were linked to more pronounced underestimation. However, this study did not examine subsequent regulation processes, was correlational in nature, and focused exclusively on achievement emotions, with high-school students attending a German *Gymnasium* (i.e., upper-track secondary school), without considering the role of perceived control and value for inducing emotions and affecting self-regulated learning.

The aim of the present study was to investigate the impact of an intervention designed to enhance reading enjoyment through increasing perceived control and value on text comprehension, judgment accuracy, and regulation effectiveness. In doing so, it extended prior research in several important ways. First, in addition to comprehension and metacomprehension accuracy, it examined the effectiveness of regulation as indicated by improvements in comprehension following a rereading phase. Second, by successfully manipulating perceived control, it enabled causal inferences for this factor. Third, by focusing on 7th-grade students in an authentic classroom setting, it extended laboratory-based findings with university students (see, e.g., De Bruin and van Gog, 2012; Prinz et al., 2020) to a younger population with lower academic achievement levels. We expected significant differences between the intervention and control groups in text comprehension, metacomprehension accuracy, and regulation effectiveness in terms of improvements in comprehension.

Literature review

Enjoyment and text comprehension

According to the control-value theory of Pekrun's (2000), achievement emotions arise from two factors. The first factor is learners' perceived control, referring to the extent to which they believe they can successfully complete a task. The second factor is learners' perceived value, which reflects the importance they assign to a task or its outcome. For example, a learner who believes to have the ability to perform well on a task (i.e., high control) and considers the task important (i.e., high value) is likely to experience enjoyment (e.g., Pekrun et al., 2011). Current extensions of the theory also consider epistemic, social, and existential emotions, highlighting the relevance of control-value processes for diverse learning and educational contexts (Pekrun, 2024).

As a positive-activating achievement emotion, enjoyment typically supports motivation and attention, facilitating learners' academic performance (e.g., Goetz and Hall, 2013; Pekrun et al., 2007; Pekrun et al., 2017; Schoenherr et al., 2025). This is also supported by recent meta-analyses (Camacho-Morles et al., 2021; Xie et al., 2025), showing

that positive emotions such as enjoyment are positively associated with academic performance. Notably, this association was especially pronounced among secondary school students (Camacho-Morles et al., 2021), suggesting age-related differences in the impact of enjoyment on academic achievement.

The extent to which the positive relation between enjoyment and performance applies specifically to text comprehension is less clear. Prinz-Weiß et al. (2022) found no association between enjoyment and text comprehension. In contrast, Zaccoletti et al. (2020) reported a positive association between activating-positive achievement emotions, including enjoyment, hope, and pride, and reading comprehension. Similarly, Li and Gan (2022) found that reading efficacy and enjoyment, alongside vocabulary knowledge, predicted students' English reading comprehension, demonstrating that enjoyment plays a key role in text comprehension.

To conclude, with the exception of the study by Prinz-Weiß et al. (2022), research suggests that greater enjoyment is typically associated with better text comprehension (e.g., Camacho-Morles et al., 2021; Zaccoletti et al., 2020; Pekrun, 2021; Li and Gan, 2022).

Enjoyment and metacomprehension accuracy

There are various measures of metacomprehension accuracy (e.g., Jaeger and Wiley, 2014). One measure is bias, defined as the signed deviation between judged and actual performance, which captures the extent to which individuals over- or underestimate their comprehension. In metacomprehension research, learners are often asked to predict their comprehension after reading but before completing test questions, which commonly reveals a tendency toward overestimation (e.g., Maki et al., 2005; Prinz et al., 2020).

A central explanation for these inaccurate judgments is offered by the cue-utilization framework (Koriat, 1997), which posits that learners base their judgments on available cues. However, these cues vary in diagnosticity, that is, in the degree to which they predict actual comprehension (e.g., Griffin et al., 2009; Oudman et al., 2018). Situation-model cues (i.e., cues related to the deeper understanding of a text), such as the ability to reproduce key conceptual relations reported in a text, are typically closely related to comprehension and thus yield high metacomprehension accuracy (e.g., Van de Pol et al., 2021). In contrast, memory-based cues (i.e., cues related to the memory of specific textual information), like the amount of textual information retrievable from memory (e.g., Dunlosky, 2005), or heuristic cues, like familiarity with the domain (e.g., Glenberg et al., 1987), do not necessarily correspond to comprehension and therefore often impair metacomprehension accuracy (e.g., Thiede et al., 2010; Jaeger and Wiley, 2014).

The relationship between achievement emotions and metacomprehension accuracy has rarely been investigated. Prinz-Weiß et al. (2022) were the first to examine the extent to which different positive and negative achievement emotions experienced during reading a text are related to metacomprehension judgments and their accuracy. Their results showed that enjoyment was used as a cue, because higher enjoyment was associated with higher predictions. Moreover, higher enjoyment was associated with greater overestimation. In a subsequent study, Prinz-Weiß et al. (2023) investigated the achievement emotion of hope during reading. The

results likewise indicated that hope was used as a cue, in the way that higher hope was linked to higher predictions. No association between hope and prediction accuracy was found.

Although the study by Prinz-Weiß et al. (2022) provided important insights, its correlational design limits causal conclusions that can be drawn. Experimental research is needed to shed further light on the role of enjoyment and its antecedents for metacomprehension accuracy and following regulation processes.

Enjoyment and regulation effectiveness

The more accurately learners judge their text comprehension, the more effectively they can make regulatory decisions, such as about which textual information to reread, ultimately leading to improved comprehension (e.g., Dunlosky and Rawson, 2012; Thiede et al., 2003). However, research has shown that learners, and particularly school students, often struggle to effectively regulate their learning from text (see, e.g., De Bruin et al., 2011; De Bruin and van Gog, 2012).

To assess the effectiveness of learners' regulation, studies typically examine the intraindividual correlation between learners' judgments and their selection of texts for rereading from a set of texts. Studies have shown that learners use their judgments of their text comprehension to decide which texts they should revisit (e.g., Thiede et al., 2003, 2012). However, when these judgments are inaccurate, the regulation decisions based on them are suboptimal too and, consequently, less effective. In contrast, more adequate text selection due to more accurate judgments is associated with significant improvements in comprehension as assessed during a second comprehension test following the regulation phase (e.g., De Bruin et al., 2011; Thiede et al., 2003, 2012).

To date, little research has focused on the question of whether achievement emotions affect self-regulation. Pekrun et al. (2002) report investigations into the relationship between achievement emotions and self-regulation among university and school students. Positive emotions, namely enjoyment and hope, were positively associated with students' perceived self-regulation concerning the goals of learning, the material used, the learning strategies employed, and the monitoring and evaluation of outcomes (as opposed to external regulation by others). This outcome suggests that enjoyment may foster learners' regulation processes. Nonetheless, Pekrun et al. (2002) used self-reports to assess self-regulation. Although self-reports provide valuable insights, they rely on learners' perceptions and do not offer direct evidence of actual regulatory processes. Extending this research with more direct evidence, Zheng et al. (2023) showed that enjoyment is positively related to the use of metacognitive strategies, underscoring that enjoyment may enhance effective self-regulated learning. A central research gap in the field of achievement emotions and self-regulated learning remains the investigation of the actual effectiveness of regulation processes, in terms of improvements in learning outcomes, particularly in the context of text-based learning.

The present study

In this study, we investigated the influence of enjoyment experienced while reading a text on comprehension, the accuracy of metacomprehension judgments in terms of over- and underestimation,

and the effectiveness of regulation as indicated by improvements in comprehension following a rereading phase. We conducted a field experiment with lower-secondary-school students attending a German *Realschule* (i.e., intermediate secondary school).

In Germany, Realschulen cover grades 5 through 10 and emphasize practical, career-oriented education. Investigating self-regulated learning processes among students in this intermediate educational track is particularly important. Previous research on metacomprehension accuracy and regulation has predominantly focused on university students (see, e.g., Prinz et al., 2020). Moreover, the study by Prinz-Weiß et al. (2022) on achievement emotions and metacomprehension was conducted with high-school students attending the upper level of an academic-track secondary school (German *Gymnasium*). Compared to high-school or university students, secondary-school students often show lower performance in key competence areas such as science and reading (e.g., Heine et al., 2023; OECD, 2019), along with weaker skills in judging and regulating their own comprehension (e.g., De Bruin et al., 2011; Prinz et al., 2020). Hence, the present study offers valuable insights into metacomprehension accuracy and regulation processes among younger learners with lower academic achievement levels.

To experimentally induce enjoyment, we developed an innovative intervention aimed at increasing students' perceived control and value regarding the learning topic. In particular, in this intervention, students watched a short video and completed a writing task. We focused on enjoyment in this study because it is among the most commonly experienced emotions by students in educational settings (e.g., Raccanello et al., 2019) and hence of high practical relevance.

Previous research has shown that positive achievement emotions such as enjoyment mostly have a positive influence on learning (e.g., Camacho-Morles et al., 2021; Pekrun et al., 2017; Pekrun, 2024) and text comprehension in particular (e.g., Zaccoletti et al., 2020). We therefore expected a significant difference in text comprehension between the intervention and control groups, with students in the intervention group showing higher text comprehension (H1).

Regarding judgment accuracy, a previous correlational study has indicated that higher enjoyment is linked to greater overestimation of text comprehension (Prinz-Weiß et al., 2022). Hence, we hypothesized a significant difference in metacomprehension accuracy between the intervention and control groups, with students in the intervention group (a) exhibiting greater overestimation of their text comprehension and (b) producing a higher percentage of overconfident judgments (H2).

Inaccurate judgments of comprehension hinder effective regulation, which ultimately impairs comprehension (e.g., Dunlosky and Rawson, 2012). Thus, we expected a significant difference in text-comprehension improvement after regulation between the intervention and control groups, with students in the intervention group showing a lower improvement (because they should be more overconfident; H3).

Methods

Sample and design

Based on previous research (Prinz-Weiß et al., 2022), we expected to find small to medium effects in our study. An *a*

priori power analysis, conducted using *G*Power* (Version 3.1; Faul et al., 2007), yielded a required sample size of $N = 260$ ($\alpha = 0.05$, $\beta = 0.20$, $d = 0.35$). To account for potential dropout, we collected data from $N = 324$ seventh-grade students attending *Realschulen* in southern Germany (i.e., in Baden-Wuerttemberg). Data collection took place from January to March 2024. Schools were contacted via email, and those expressing interest in participating were included in the study (i.e., opportunity sampling). Eligible were 7th-grade classes that had not previously covered the topics of ocean acidification or climate zones. Overall, students from 15 classes in 6 schools were tested. Students were excluded from the analyses if they (a) had been diagnosed with dyslexia ($n = 36$), (b) did not speak German at a sufficiently advanced level (i.e., indicated that they could speak and understand only simple sentences in German; $n = 12$), (c) completed the comprehension test in an unreasonable short amount of time (i.e., two standard deviations below the mean; $n = 1$), (d) did not answer all comprehension questions ($n = 3$), or (e) did not receive a full point in the blog entry ($n = 80$). Together, the data of $n = 107$ students was excluded from the analyses. The remaining students were, on average, 12.56 ($SD = 0.72$) years old; $n = 113$ students (52%) were male, $n = 98$ students (45%) were female, one student (0.5%) was non-binary, one student (0.5%) did not identify with any gender, and four students (2%) chose not to disclose their gender. Their average German grade was 2.69 ($SD = 0.73$; 1.00 representing the highest and 6.00 the lowest grade).

Before conducting the study, we preregistered our hypotheses and methods on the Open Science Framework (OSF) at https://osf.io/qsej4/?view_only=8d55a48405984ad5a1f7cdfd6f3fd85f. The study was approved by the ethics committee of the university the authors were associated with (approval code: AZ20231018) as well as by the Ministry of Education and Cultural Affairs (i.e., Kultusministerium) in which the participating classes were located (i.e., Baden-Wuerttemberg). The students and their legal guardians were informed about the study in advance with an information letter and gave their written consent. Participation was voluntary and could be withdrawn at any time without justification. All participants were treated anonymously. Personal identifiers such as names or place of residence were not collected.

The present empirical study is a randomized experimental field study employing a one-factorial between-subjects design, with the intervention type (enjoyment intervention vs. control intervention) as the predictor variable (see, e.g., Ato et al., 2013). The participants were randomly assigned to the enjoyment intervention ($n = 95$) or the neutral intervention ($n = 122$). The dependent variables were text comprehension, judgment accuracy, and regulation effectiveness (i.e., improvement in text comprehension).

Material

Enjoyment intervention

To induce enjoyment in the experimental intervention, participants (a) watched a video and (b) completed a writing task. Based on the control-value theory of achievement emotions (Pekrun, 2000, 2006), the video and writing task were intended to enhance participants' perceived value and control with regard to learning the content of the upcoming text.

(a) In the video, to increase perceived *value* of the learning content (i.e., consequences of increased CO_2 emissions for the oceans), the participants were provided with three reasons why knowledge about consequences of increased CO_2 emissions is important and why they should therefore acquire this knowledge. As an example, one argument stated that individuals can only critically reflect on their own actions if they possess this knowledge. For instance, people can only question whether using a car for short distances is prudent if they know that cars (powered by internal combustion engines) emit harmful CO_2 into the environment.

In order to increase perceived *control* over learning the content, the video explained that the brain can grow and become stronger through challenging tasks, just like muscles, and that therefore everyone is capable of acquiring this knowledge.

The video lasted 3.35 min. To direct students' attention to the content of the video and minimize extraneous cognitive load, the visual design was kept simple and clear, symbolically reinforcing the information presented orally (see Figure 1). The video could only be watched once and it was not possible to pause the video.

(b) Following the video, the participants were instructed to write a blog entry for the school homepage. Specifically, in the blog entry, they were asked to provide the three arguments from the video for why knowledge about consequences of increased CO2 emissions is important. Based on the results of a pilot study, the three arguments were shortly repeated in the writing task instructions. Specifically, the participants were asked to mention these three arguments within their blog entry. Additionally, in the blog entry, they had to emphasize the fact that everyone can acquire this knowledge. The writing task served to repeat and consolidate the information presented in the video. This approach of combining a passive instructional phase (i.e., watching a video) with active training content (i.e., writing a blog entry) was adopted from mindset interventions. These interventions typically convey theoretical knowledge about the malleability of abilities and include reflection tasks to strengthen the internalized belief in a growth mindset (see, e.g., Zeeb et al., 2020).

Participants' answers to the writing task were scored in the following way: For providing an argument why knowledge about consequences of increased CO_2 emissions is important, participants

FIGURE 1
Screenshot from the enjoyment-intervention video at 3.08 min.
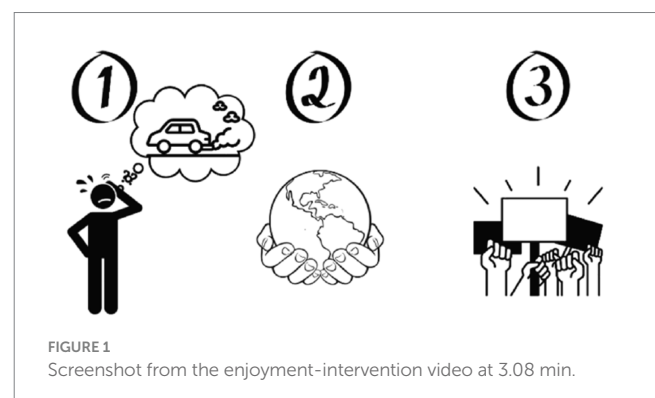
received 1 point. Participants received 0.5 points if they provided only an example instead of a general argument. For mentioning that everyone can learn about the consequences of increased CO_2 emissions, participants received 1 point. Thus, participants could achieve a maximum of 4 points in the writing task.

Neutral intervention

The neutral intervention was intended to have no impact on participants' emotional state. Analogous to the enjoyment intervention, it consisted of (a) a video and (b) a writing task, ensuring that the time and effort required were equal across both conditions. The video and writing task addressed a topic from the same subject but not directly relevant to the learning content, namely, climate zones, and were not supposed to affect participants' perceived value and control.

(a) The video explained what climate zones are, which climate zones can be distinguished, and in which aspects they differ. The video lasted 3.24 min. Similar to the video in the enjoyment intervention, the visual design was simple and clear (see Figure 2), and it could only be watched once without the option to pause. Both the enjoyment and neutral intervention videos can be accessed via the following link: https://osf.io/v6nx3/?view_only=014304e91aef490b810d87184065e9c3

(b) Following the video, the participants were instructed to write a blog entry for the school homepage. In the blog entry, they were asked to define climate zones, identify which ones exist, explain how they can be distinguished, and indicate which climate zone Germany is located in. One point was awarded for each correct answer. If an answer was correct but incomplete, participants received 0.5 points. Thus, a maximum of 4 points could be achieved.

Text

The science text used in this study was an expository text that dealt with the ecological topic *Consequences of Increased CO₂ Emissions for the Oceans*. This topic was chosen because it has a rather negative connotation, making it unlikely to induce enjoyment on its own. This is due to the fact that it addresses environmentally threatening consequences, such as ocean acidification and loss of biodiversity, which are typically perceived as concerning rather than enjoyable. Moreover, the topic is not part of students' grade-level curriculum in the state where the study was conducted (Ministerium fuer Kultus, Jugend und Sport Baden-Wuerttemberg, (2022)).

FIGURE 2
Screenshot from the neutral intervention video at 3.12 min.
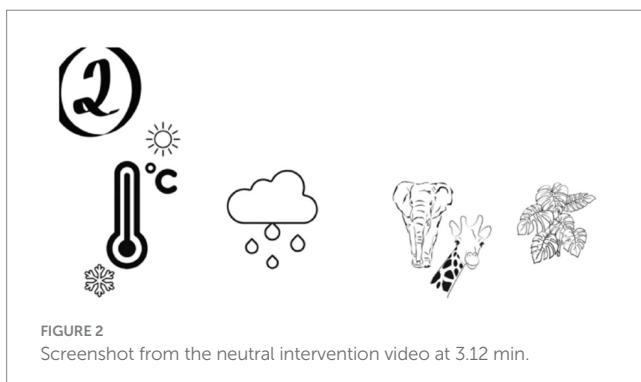
Therefore, it should not have been covered in the students' classes before, which was also confirmed by all participating teachers, and the participants should have no to low prior knowledge. The text was written on the basis of various articles on the internet and textbooks (e.g., Begon et al., 2017). The text contained 562 words and was divided into six sections, with each section containing a key message. The Flesch-Reading-Ease score (Flesch, 1948) was 55, indicating that the text was fairly difficult to read. This provided an opportunity for measurable improvements in text comprehension following a regulation phase.

Measures

Perceived value and control

To examine whether the enjoyment intervention was successful in increasing students' perceived value and control, we assessed these two constructs. Perceived value was measured using 8 items from the Task Value Questionnaire (Shao et al., 2020). An example item is "I found learning the content very interesting." To assess perceived control, 8 items of the Perceived Academic Control Scale (Perry et al., 2001) were used. An example item is "How well I understood the content was a 'matter of luck.'" The participants indicated their agreement with each item on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). For both perceived value and perceived control, prior research demonstrated unidimensional factor structures with factor loadings ranging from 0.43 to 0.66 for control and from 0.35 to 0.69 for value, and reported good to very good model fit indices (control: CFI = 0.95, TLI = 0.93, RMSEA = 0.06, SRMR = 0.04; value: CFI = 0.95, TLI = 0.93, RMSEA = 0.06, SRMR = 0.04), providing support for the scales' construct validity (Shao et al., 2020). Moreover, internal consistency was marginal for perceived control (Cronbach's α = 0.58; Cronbach, 1951) and good for perceived value (Cronbach's α = 0.85) in the present study.

Enjoyment

We assessed participants' state enjoyment with the Achievement Emotions Questionnaire (Pekrun et al., 2011). The questionnaire provides 6 items for assessing learning-related enjoyment. The items were adapted to align with the context of learning by reading a text. An exemplary item is "I enjoyed learning the content." The participants were instructed to report how they felt during studying the text. Their agreement with each item was indicated on a 5-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Previous research demonstrated unidimensional factor structures with factor loadings ranging from 0.71 to 0.81, and reported good to very good model fit indices (CFI = 0.99, TLI = 0.86, RMSEA = 0.06, 90% CI [0.020, 0.101], SRMR = 0.02), providing support for the scale's construct validity (Sadoughi and Hejazi, 2024). Internal consistency was good in the present study (Cronbach's α = 0.88; Cronbach, 1951), consistent with previous research (e.g., Sadoughi and Hejazi, 2024, α = 0.90).

Text comprehension

Comprehension of the text was assessed with 6 inference questions (one question per section), which captured participants' deeper understanding with regard to the key message of the text. The questions had a multiple-choice format with four response options of

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What is meant by the process of ocean acidification?

○ a) Rising water temperatures make the water more acidic.

○ b) Carbonic acid is formed from CO_2 and water.

○ c) Oxygen reacts with CO_2 to form acid.

○ d) The water becomes more acidic due to increasing salinity.

FIGURE 3
Example question of the comprehension test. The correct answer is b) "Carbonic acid is formed from CO_2 and water".

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which only one was correct. For an example question assessing text comprehension, see Figure 3.

For selecting the correct option, 1 point was awarded. Zero points were awarded for choosing an incorrect option. Hence, a maximum of 6 points could be achieved.

Measures of self-regulated learning

Self-regulated learning encompasses the components of planning, monitoring, and regulation. Planning involves setting goals and selecting strategies, monitoring refers to assessing one's understanding or performance, and regulation entails adjusting one's learning strategies (e.g., Zimmerman, 2002). In this study, we focused on the dimensions of monitoring and regulation. Monitoring was assessed via judgment accuracy, while regulation was measured as the change in text comprehension from before to after a rereading phase. Planning was not investigated because the text and reading time were fixed, constraining participants' planning opportunities. This design choice ensured that the planning aspect remained constant across participants.

Judgment accuracy

Judgments were assessed in terms of predictions. That is, after reading the text but before seeing any questions, the participants had to estimate how many comprehension questions they would presumably answer correctly (from 0 to 6 questions).

Judgment accuracy was operationalized in two ways. First, as bias, which is the signed difference between a participant's judged and actual number of correctly answered comprehension questions (e.g., Schraw, 2009). A positive value indicated overestimation, a negative value indicated underestimation, and a value of 0 indicated a perfectly accurate prediction. Second, judgment accuracy was assessed as the percentage of overconfident judgments, with overconfident judgments coded as 1 and all other judgments (accurate or underconfident) coded as 0.

Regulation effectiveness

Text comprehension was measured twice, once before and once after a regulation phase. For this purpose, the same questions were presented to the participants a second time, without showing the options they had selected previously. The effectiveness of regulation was determined by examining the change in text comprehension from the first to the second comprehension test.

Prior knowledge

Participants' prior knowledge was assessed by asking one open-ended question. Specifically, participants were asked to write down everything they knew about the consequences of increased CO_2 emissions for the oceans. Participants received 1 point for each consequence they provided. Two raters scored participants' responses independently. A Cohen's of $\kappa = 0.85$, 95% CI [0.79, 0.92] indicated high inter-rater agreement.

Potential covariates

Students' prior knowledge and their most recent German grade were considered as potential covariates. Prior knowledge was assessed because research has shown that students with higher prior knowledge tend to achieve better text comprehension and more accurate metacomprehension, as higher topic knowledge is associated with more accurate predictions of one's own comprehension performance (e.g., Griffin et al., 2009). German grade was used as an indicator of general language skills, which are typically also associated with better text comprehension and more accurate metacomprehension (e.g., Rodrigues et al., 2023).

Analytic strategy

First, as manipulation checks, participants' perceived value, perceived control, and enjoyment were compared between the experimental and control intervention groups using independent-samples t tests. Moreover, intraclass correlation coefficients (ICC) were calculated to assess the influence of class membership on the dependent variables. Next, students' prior knowledge and most recent German grade were compared between the groups with independent-samples t tests and correlated with the dependent variables to determine whether they should be included as covariates in the main analyses (for details, see the Results section, "Potential Control Variables" and the relevant results subsections on covariate inclusion). Then, our hypotheses regarding text comprehension (H1) and metacomprehension accuracy (H2) were tested. Text comprehension was analyzed using an ANCOVA with prior knowledge as a covariate, whereas judgment accuracy was examined using independent-samples t tests. In addition, performance on the first comprehension test was examined to exclude ceiling effects and confirm the possibility of improving text comprehension through regulation. Our hypothesis concerning regulation effectiveness (H3) was tested using a mixed-design ANCOVA with testing time (pre- vs. post-regulation) as the within-subjects factor and intervention type as the between-subjects factor, including prior knowledge and German grade as covariates. Planned *post hoc* analyses were intended to explore pairwise differences if significant effects emerged. Exploratory analyses further examined (a) correlations of perceived control, perceived value, and enjoyment with the dependent variables, (b) rereading time and (c)

changes in comprehension across the two testing phases (i.e., improved, declined, or unchanged). For all analyses, when test assumptions were violated, alternative approaches such as non-parametric tests were employed.

Procedure

The study was conducted during the participants' regular German classes. First, participants received general instructions about the aim, procedures, and tasks of the study. They were informed that participation was voluntary and could be withdrawn at any time without giving reasons, and that the results and collected data would be published. Subsequently, they answered the prior knowledge question within 90 s. Thereafter, the intervention started, and participants watched a video corresponding to their assigned condition while wearing headphones. They were informed that after the video they would receive a writing task and that they should therefore follow the video carefully. For completing the writing task (i.e., writing a blog entry), they had a maximum time of 5 min. After the time had elapsed, participants were automatically directed to the next page. They received the text to read for 6 min and 30 s and were required to spend the entire time reading the text, without the option to advance early. They were instructed to focus on the text thoroughly and were informed that their understanding of the text would be tested later in the study. Afterwards, participants answered the items on their perceived value and control and, next, on their enjoyment. When answering these items, they were instructed to choose the answer that first came to mind. Thereafter, participants predicted their comprehension. To do so, they were informed about the kind, format, number, and completion time of the upcoming comprehension questions. Afterwards, they had up to 9 min to complete the comprehension test. Once participants had completed all questions, they could click 'Continue'. After answering the questions for the first time, they had the opportunity to regulate their text comprehension. Specifically, within a maximum time limit of 3 min, participants could decide for how long they wanted to restudy the text. Thereafter, they answered the comprehension questions for the second time, with a time limit of 5 min. Finally, the participants answered demographic questions.

To set reasonable time limits, all time constraints were tested in a pilot study and chosen accordingly. Moreover, all time limits were displayed with a countdown timer in the top right-hand corner of the screen. In total, the study lasted about 45 min (i.e., one school lesson). An overview of the entire study procedure is provided in Figure 4.

Results

According to Cohen (1988), effect sizes of $\eta^2 = 0.01$, 0.06, and 0.14 are considered thresholds for small, medium, and large effects, respectively. For the correlation coefficient r, values of 0.10, 0.30, and 0.50 serve as benchmarks for small, medium, and large effects. In the case of mean differences, Cohen's d values of 0.20, 0.50, and 0.80 are regarded as indicative of small, medium, and large effects. For the coefficient of determination R^2, values of 0.01, 0.09, and 0.25 are considered to represent small, medium, and large effects. Finally, Cramér's V values of 0.10, 0.30, and 0.50 are commonly interpreted as

small, medium, and large effects. The descriptive statistics of the variables are presented in Table 1. To facilitate the interpretation of the results, we report the dependent variables in percentages. All statistical analyses were conducted using *IBM SPSS Statistics* (Version 30).

Manipulation checks

As enjoyment was intended to be induced through increasing perceived value and control, a manipulation check was conducted on these variables as well as on enjoyment. The analyses revealed a significant difference between the two groups in perceived control, $t(215) = 2.01$, $p = 0.046$, $d = 0.28$. The experimental group perceived significantly higher control than the control group. However, the manipulation did not lead to a significant increase in perceived value in the experimental group compared to the control group, $t(215) = 0.72$, $p = 0.471$, $d = -0.04$. Likewise, there was no significant difference in reported enjoyment between the two groups, $t(215) = 0.11$, $p = 0.912$, $d = 0.02$. Overall, these results suggest that the manipulation was only partially successful. Specifically, the two groups differed significantly only in perceived control but not in perceived value or enjoyment. Hence, any emerging group differences should be interpreted in terms of differences in perceived control.

Performance check

Only $n = 11$ (5%) students answered all six comprehension questions correctly prior to the regulation phase. Moreover, on average, text comprehension prior to regulation was 52% ($SD = 46\%$). This indicated that there were no ceiling effects and that the comprehension questions had an adequate level of difficulty, leaving room for improvement in text comprehension through regulation.

Intraclass correlation coefficient (ICC)

Given the hierarchical structure of the data, we examined the influence of group membership on the depended variables by calculating the intraclass correlation coefficient (i.e., ICC(1)). This coefficient indicates the proportion of variance in a dependent variable that is explained by differences between groups—in this case, the 15 classes.

All ICC(1) values were low and, except for text comprehension after regulation, below the commonly accepted threshold of 0.05 (Heck et al., 2014; see Table 2). Text comprehension after regulation exhibited a slightly higher ICC(1) of 0.069, which still constitutes a small effect. These results suggest that class membership accounted for only a small proportion of the variance in the dependent variables. Consequently, we did not pursue multilevel analyses.

Potential control variables

Students' prior knowledge and grade in German were considered as potential control variables. The groups did not differ significantly in prior knowledge, $t(215) = 1.25$, $p = 0.212$, $d = 0.17$. However, students in the experimental group had significantly better grades in their most recent German grade report than those in the control group, $t(215) = -2.80$, $p = 0.006$, $d = -0.38$. As several variables showed deviations from normality, Spearman correlations were conducted to examine the relationships between the potential covariates and the dependent variables (see Table 3). Prior knowledge

was significantly positively correlated with text comprehension both before and after the regulation phase. German grade showed a significant negative correlation with text comprehension after regulation. Based on these significant correlations, prior knowledge and German grade were included as covariates in the respective analyses.

Enjoyment and text comprehension

An ANCOVA with prior knowledge as a covariate was conducted to examine the influence of the intervention type on text comprehension prior to the regulation phase. Prior knowledge had a significant impact on text comprehension, $F(1, 214) = 6.61$, $p = 0.011$, $\eta^2 = 0.03$. Intervention type also had a significant effect on text comprehension, $F(1, 214) = 4.64$, $p = 0.032$, $\eta^2 = 0.02$. This shows that text comprehension was significantly higher in the experimental group ($M = 56\%$, $SD = 27\%$) than in the control group ($M = 48\%$, $SD = 21\%$) after controlling for prior knowledge. Notably, a significant group difference was also observed when prior knowledge was not controlled for, $t(177) = 2.29$, $p = 0.023$, $d = 0.32$.

The overall model was significant, $F(2, 214) = 6.14$, $p = 0.003$, $R^2 = 0.045$, indicating that prior knowledge and intervention type contributed significantly to explaining variance in text comprehension, although the proportion of explained variance was rather small.

The text comprehension hypothesis (H1) can thus be confirmed. Participants who received an intervention aimed at increasing enjoyment demonstrated higher text comprehension prior to the regulation phase compared to those in the control group. However, this difference is likely attributable to an increase in perceived control rather than enjoyment, as the intervention was effective only with regard to perceived control.

Enjoyment and judgment accuracy

To test the effect of the intervention type on judgment accuracy, an independent samples t test was conducted. Before regulation, the experimental group accurately judged their text comprehension ($M = 0\%$, $SD = 30\%$), and the control group slightly overestimated their text comprehension ($M = 6\%$, $SD = 24\%$). A t test revealed no significant difference in overestimation bias between the groups,
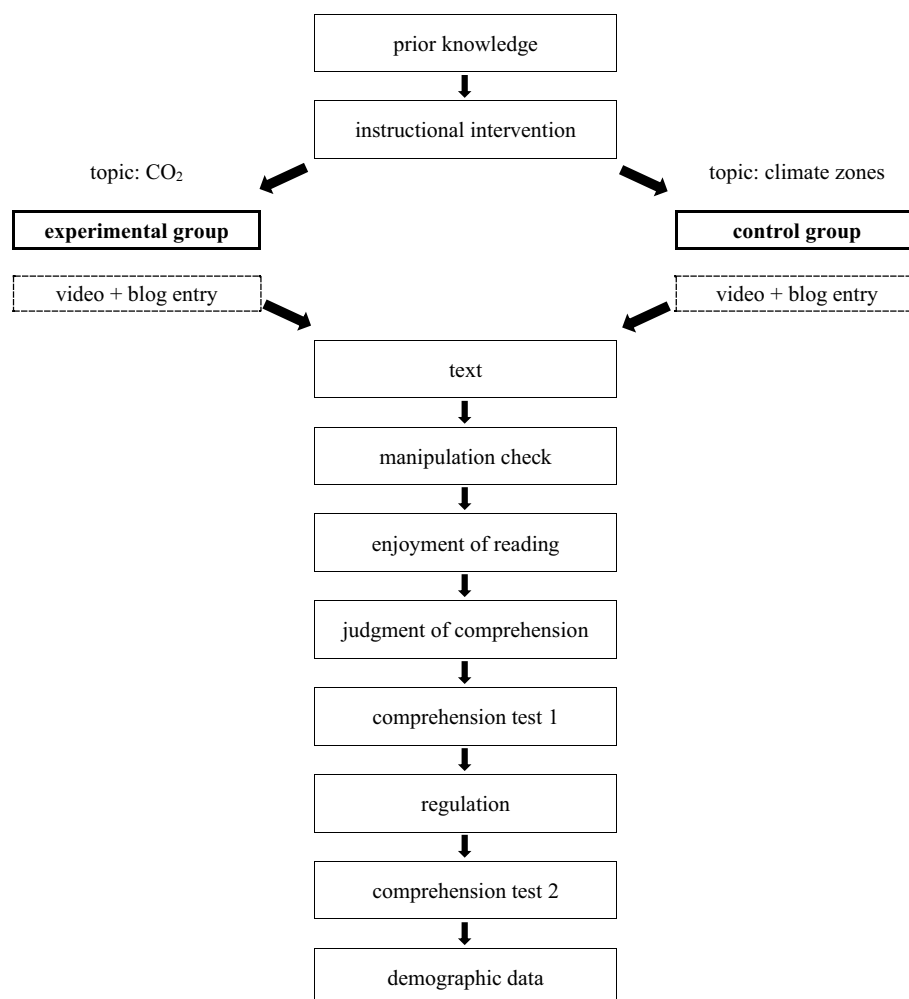

FIGURE 4
Study procedure.

TABLE 1 Descriptive statistics.

Variable	Experimental group (n = 95)		Control group (n = 122)		Overall sample (N = 217)	
	M	SD	M	SD	M	SD
Age (in years)	12.56	0.67	12.56	0.76	12.56	0.72
Gender[a]						
Female (in %)	38		51		45	
Male (in %)	58		48		52	
Prior knowledge	0.36	0.35	0.30	0.40	0.33	0.37
German grade	2.54	0.68	2.81	0.74	2.69	0.73
Perceived control	3.52	0.51	3.38	0.52	3.44	0.52
Perceived value	3.72	0.73	3.65	0.67	3.68	0.70
Enjoyment	3.27	0.92	3.25	0.75	3.26	0.83
Intervention task score	1.85	0.80	2.11	0.81	2.00	0.82
Judgment (in %)	56	21	54	19	55	20
Judgment accuracy (in %)[b]	0	30	6	24	3	26
Text comprehension before regulation (in %)	56	27	48	21	52	24
Text comprehension after regulation (in %)	55	26	50	22	52	24
Regulation effectiveness (in %)[c]	-1	23	2	18	0	20
Regulation time (in seconds)	77.61	57.64	64.61	57.53	70.30	57.81

[a]Only students identifying as female or male are included in the table, because only one student identified as non-binary, one did not identify with any gender, and four students chose not to disclose their gender.
[b]Judgment accuracy in terms of bias was calculated as the signed difference between a participant's judgment and actual performance on the comprehension test prior to the regulation phase.
[c]Regulation effectiveness reflects the change in text comprehension from pre- to post-regulation.

$t(215) = -1.51$, $p = 0.133$, $d = -0.21$. Notably, the direction of the means suggests a trend opposite to the hypothesized effect, although the degree of overestimation was relatively low.

Since computing an average bias score may result in positive (overconfidence) and negative (underconfidence) values canceling each other out, judgment accuracy was additionally operationalized based on the percentage of overconfident judgments. To do so, overconfident judgments were coded as 1, and other judgments (accurate and underconfident) as 0. The results showed that 37% of participants in the experimental group overestimated their comprehension, compared to 43% in the control group. A chi-square test revealed no significant difference in the frequency of overconfident judgments between the groups, $\chi^2(1) = 1.22$, $p = 0.270$, Cramér's V = 0.08. Therefore, the judgment accuracy hypothesis (H2) was not confirmed.

Enjoyment and regulation effectiveness

To examine whether text comprehension changed over the course of the regulation phase (i.e., regulation effectiveness) differently depending on the intervention type, a mixed-design ANCOVA was conducted. Testing time (pre- vs. post-regulation phase) served as a within-subject factor, and intervention type (experimental vs. control) as a between-subjects factor. Prior knowledge and German grade were included as covariates. The dependent variable was text comprehension.

Descriptively, in both intervention groups, text comprehension changed only minimally over the course of the regulation phase. In

TABLE 2 ICC(1)s for the dependent variables.

Variable	ICC(1)
Text comprehension before regulation	0.046
Judgment accuracy	0.005
Text comprehension after regulation	0.069
Regulation effectiveness	> 0.001

the experimental group, comprehension was 56% ($SD = 27\%$) before regulation and 55% ($SD = 26\%$) after regulation. In the control group, comprehension increased slightly from 48% ($SD = 21\%$) before regulation to 50% ($SD = 22\%$) after regulation.

The analysis revealed no significant main effect of the time point, $F(1, 213) = 1.94$, $p = 0.165$, $\eta^2 = 0.01$, indicating that text comprehension did not change significantly from pre- to post-regulation across groups. The main effect of the intervention type was also not significant, $F(1, 213) = 2.51$, $p = 0.115$, $\eta^2 = 0.01$, indicating no statistically significant overall difference in text comprehension between the experimental and control groups. Finally, there was no significant interaction effect between time point and intervention type, $F(1, 213) = 1.59$, $p = 0.208$, $\eta^2 = 0.01$. This means that the change in comprehension over time did not significantly differ between the experimental and control groups. Overall, there was little evidence of effective regulation; average comprehension showed minimal improvement in the control group and even a slight decline in the experimental group. Contrary to the regulation effectiveness hypothesis (H3), regulation was not less effective in the experimental group compared to the control group.

A significant main effect was found for prior knowledge, $F(1, 213) = 6.26$, $p = 0.013$, $\eta^2 = 0.03$. Participants with greater prior knowledge achieved better overall comprehension scores. In contrast, German grade showed no significant effect, $F(1, 213) = 2.47$, $p = 0.118$, $\eta^2 = 0.01$.

To examine whether the inclusion of covariates influenced the results, the analysis was repeated without controlling for prior knowledge and German grade. This analysis also revealed no significant main effect of time point, $F(1, 215) = 0.02$, $p = 0.882$, $\eta^2 < 0.01$, and no significant interaction effect between time point and intervention type, $F(1, 215) = 1.06$, $p = 0.303$, $\eta^2 = 0.01$. However, a significant main effect of intervention type emerged, $F(1, 215) = 4.40$, $p = 0.037$, $\eta^2 = 0.02$, indicating a significant difference in text comprehension between the experimental and control groups across time points. This finding aligns with the results on text comprehension and supports our hypothesis (H1) that the different intervention types would lead to differences in comprehension.

Exploratory analyses

To gain deeper insights into the role of enjoyment for self-regulated learning from text several exploratory analyses were conducted. Specifically, we calculated the correlations between participants' enjoyment and the dependent variables, analyzed participants' rereading times, examined the percentages of underconfident and correct judgments, and assessed changes in participants' comprehension across the two testing phases.

Correlations

To investigate the relationships of the dependent variables with enjoyment as well as perceived value and control, Spearman correlations were calculated (see Table 3). Higher enjoyment was significantly associated with better text comprehension before regulation. This outcome is in line with H1, which proposed that higher enjoyment would support comprehension. Furthermore, a significant correlation was found between enjoyment and text comprehension after regulation. No significant correlations of enjoyment with judgment accuracy or regulation effectiveness emerged. Thus, no support was found for the assumption that higher

enjoyment is associated with greater overestimation of comprehension (H2) or lower regulation effectiveness (H3). These findings suggest that enjoyment is related to better comprehension but not to metacomprehension accuracy or the effectiveness of regulation.

Perceived control showed significant positive correlations with text comprehension before and after regulation. This finding aligns with the observed group differences, indicating that a higher sense of control is associated with better comprehension. Moreover, perceived control was significantly negatively related to judgment accuracy and regulation effectiveness. This finding reflected that a greater sense of control goes along with greater underconfidence and less effective regulation, although these correlations were rather small.

Perceived value also showed significant positive correlations with text comprehension before and after regulation, indicating that a higher perceived value concerning the learning content is associated with better comprehension as well. There were no significant correlations between perceived value and judgment accuracy or regulation effectiveness.

As the analyses are correlational in nature, these results do not permit causal conclusions and should be interpreted with caution.

Rereading time

There was no significant difference in rereading time between the groups, $t(215) = 1.65$, $p = 0.100$, $d = 0.23$. This result suggests that participants in both groups spent approximately the same amount of time rereading the text.

Metacomprehension accuracy

As indicated above, because positive (overconfidence) and negative (underconfidence) values can cancel each other out, judgment accuracy was additionally operationalized based on the percentage of overconfident, underconfident, and accurate judgments. For the results on the percentage of overconfident judgments, see the section on Enjoyment and Text Comprehension. To quantify the percentage of underconfident judgments, underconfident judgments were coded as 1, and accurate and overconfident judgments as 0. To assess the percentage of accurate judgments, accurate judgments were coded as 1, and underconfident and overconfident responses as 0.

TABLE 3 Correlations between the study variables.

Variable	1	2	3	4	5	6	7	8	9	10
1. Prior knowledge	-									
2. German grade	−0.23**	-								
3. Perceived control	0.23**	−0.14*	-							
4. Perceived value	0.18**	−0.10	0.46**	-						
5. Enjoyment	0.08	−0.05	0.40**	0.76**	-					
6. Text comprehension before regulation	0.17*	−0.09	0.39**	0.24**	0.19**	-				
7. Judgment	0.19**	−0.14*	0.30**	0.30**	0.25**	0.30**	-			
8. Judgment accuracy	−0.00	−0.00	−0.16*	0.01	0.02	−0.70**	0.40**	-		
9. Text comprehension after regulation	0.18**	−0.16*	0.29**	0.17*	0.13	0.63**	0.28**	−0.41**	-	
10. Regulation effectiveness	0.00	−0.09	−0.15*	−0.09	−0.11	−0.39**	−0.00	0.35**	0.42**	-

*$p < 0.05$; **$p < 0.01$.

A chi-square test revealed a significant difference in underestimations of text comprehension between the groups, $\chi^2(1) = 7.59$, $p = 0.006$, Cramér's V = 0.19, with underestimations occurring more frequently in the experimental group than in the control group. No significant differences were found for accurate judgments, $\chi^2(1) = 2.98$, $p = 0.085$, Cramér's V = 0.12. The corresponding means and standard deviations are presented in Table 4.

Changes in comprehension

For each question, it was assessed whether the response in the first testing phase was correct or incorrect and whether and how the answer changed in the second testing phase. A question was classified as *improved* if it was answered incorrectly in the first test and correctly in the second. Conversely, if a response changed from correct to incorrect, it was classified as *declined*. If an answer remained the same across both testing phases (either correct or incorrect), it was classified as *unchanged*.

For each participant, the total number of questions showing an improvement, a decline, or no change across all six comprehension questions was then calculated. First, changes in text comprehension within the experimental and control groups were examined. In the experimental group, 11.3% of the students' answers improved, 12.7% decreased, and 76.0% remained unchanged. In the control group, 12.2% of the students' answers improved, 10.5% decreased, and 77.3% showed no change. These analyses show that students' performance remained relatively stable after the regulation phase, and improvements in text comprehension were generally rather small.

Due to non-normal distributions of the variables, group differences were tested using Mann–Whitney U tests. These analyses revealed no significant differences between the experimental and control groups for the number of improved responses ($U = 6035.00$, $Z = 0.571$, $p = 0.568$), decreased responses ($U = 5506.00$, $Z = -0.693$, $p = 0.489$), or unchanged responses ($U = 6166.00$, $Z = 0.839$, $p = 0.401$). Thus, the degree of change in comprehension did not differ significantly between the groups.

Discussion

The present study investigated the impact of an intervention designed to enhance reading enjoyment though increasing perceived value and control on text comprehension, judgment accuracy, and the effectiveness of regulation through rereading. In contrast to previous correlational research with high-school students (Prinz-Weiß et al., 2022), this study focused on 7th-grade students in intermediate secondary schools who typically exhibit lower academic achievement, examined their regulation behavior (i.e., rereading), and used an experimental approach.

Enjoyment intervention

In the present study, the induction of perceived value in the experimental group was not successful. Hence, it is not surprising that no significant increase in enjoyment was observed in this group. The ineffectiveness of the value induction might be explained by several factors. First, the arguments presented in the video explaining

TABLE 4 Descriptive statistics of judgment accuracy in terms of percentages of overconfident, underconfident, and accurate judgments by intervention group.

Variable	Experimental group ($n = 95$)		Control group ($n = 122$)	
	M	*SD*	*M*	*SD*
Accurate judgment	0.20	0.40	0.30	0.46
Overestimation	0.37	0.49	0.44	0.45
Underestimation	0.43	0.50	0.25	0.44

why knowledge about the consequences of increased CO_2 emissions is important, which the students were supposed to reconstruct in their blog entry, might have been too complex and imposed cognitive overload. Although the video attempted to explain the arguments in a comprehensible manner, the cognitive demands may still have been too high for at least some students. This assumption is supported by the relatively low average score achieved by the students on the blog entry task. As a result, students may not have been able to fully engage with the content and grasp the arguments. In turn, their perceived value of the learning content was not enhanced. Second, the assigned task of writing a blog entry may have imposed cognitive overload. It is possible that the students focused on formal aspects such as structure and organization (e.g., introduction, outline, language), which redirected cognitive resources away from processing the content, limiting induction of perceived value. In future studies, it may be useful to reduce formal requirements. For example, participants could be asked to write down the arguments in bullet points. Moreover, they could be instructed to develop and exemplify their own arguments. This might more effectively promote active elaboration and personal relevance. Additionally, the arguments could be simplified to an even greater extent to foster their processing.

Furthermore, it is possible that the chosen text topic *consequences of increased CO_2 emissions for the oceans* was perceived as emotionally negative by participants. Although it was selected under the assumption that it would not inherently boost enjoyment, it may even have triggered negative associations. This may have interfered with the effectiveness of the enjoyment induction and could explain the lack of significant group differences in reading enjoyment. However, while it cannot be ruled out that the topic was negatively perceived, any such influence would have affected both groups equally. Future research should systematically investigate how the emotional tone or valence of a text topic influences reading enjoyment.

Despite the absence of an effect on perceived value, the manipulation of perceived control was successful. Considering the comparatively simple manipulation (i.e., the video explained that the brain grows stronger through challenging tasks like muscles, enabling everyone to acquire the knowledge), this represents a remarkable result. Given that only perceived control was effectively manipulated, any group differences should be interpreted in terms of differences in perceived control.

Text comprehension

Concerning text comprehension (H1), the experimental group demonstrated significantly higher text comprehension prior to the regulation phase than the control group. Hence, the enhanced control

perceived by students in this group likely helped them process the information presented in the text. Specifically, on a cognitive level, enhanced control may have facilitated the activation of relevant prior knowledge and more strategic encoding of key concepts, enabling deeper understanding. On a motivational level, enhanced control may have increased intrinsic motivation, persistence, and effort allocation, supporting understanding of the text. This interpretation aligns with Deci and Ryan's (1985) self-determination theory, which posits that perceived autonomy supports learners' intrinsic motivation and thereby academic performance. For instance, results by Patall et al. (2008) showed that providing choice as a way to foster autonomy enhanced intrinsic motivation, effort, and task performance, among other outcomes. In the context of our study, perceived control can be interpreted as a form of autonomy.

For teaching practice, this result means that teachers should strengthen students' sense of control. For example, similar to the video, they could inform students that learning is like training a muscle—the more you use your brain, the stronger and more efficient it becomes. Therefore, everyone can acquire knowledge with consistent effort. Alternatively, teachers could offer choices during the learning process, for example, in topic selection or work methods. Clear task structures also support feelings of control (e.g., Zimmerman, 2002). Moreover, teachers should provide targeted support and feedback to enhance students' self-efficacy and thereby their perceived control (e.g., Perry et al., 2001). Additionally, fostering a growth mindset, which is the belief that abilities can be developed through effort, is recommended. Such a mindset not only strengthens motivation, self-efficacy, and the willingness to face challenges, but also reinforces learners' perception that they can actively influence their own learning progress (Burnette et al., 2013; Yeager and Dweck, 2012). Taken together, these strategies may promote a stronger sense of control and, in turn, better comprehension.

Although participants were randomly assigned to conditions, students in the experimental group reported slightly higher grades in German. This potential difference in prior academic achievement should be taken into account when interpreting group differences in text comprehension, as it may have played a role in the observed results. Students with higher grades in German might, for example, have more experience with reading strategies or better language skills that could have supported their comprehension. Thus, it cannot be ruled out that pre-existing competencies contributed to the outcomes. Nevertheless, a higher grade in German does not necessarily reflect superior reading comprehension, as the grade encompasses a range of broader academic criteria and performance dimensions. Accordingly, German grade did not correlate significantly with text comprehension before the regulation phase in our sample, suggesting that it likely did not substantially influence initial comprehension. However, a significant negative correlation was found with text comprehension after the regulation phase (note that German grade was coded such that lower values indicate better performance), indicating that students with better German grades tended to score higher on the comprehension test after regulation.

In addition, prior knowledge had a significant positive effect on text comprehension. This finding highlights the importance of considering learners' prior knowledge when they are learning from text. This result is theoretically consistent with prior literature indicating that prior knowledge is a key predictor of learning outcomes (e.g., Simonsmeier et al., 2022).

Although the group differences in our study could not be interpreted as intended and causal conclusions are limited, the correlational analyses nevertheless provide valuable insights. Specifically, the correlation analyses showed that perceived control, perceived value, and enjoyment were significantly associated with text comprehension before regulation. Among these, perceived control showed the strongest association, further underscoring its role as a key motivational factor in learning from text, which aligns with self-determination theory (Deci and Ryan, 1985).

In accordance with expectancy-value theory (Eccles and Wigfield, 2002), students who attributed higher value to the text content might have processed it more effectively, leading to better comprehension. More precisely, perceiving the content as valuable could have promoted attention, deeper elaboration of the material, and integration with prior knowledge.

Enjoyment during reading showed a small positive correlation ($r = 0.19$) with text comprehension. Prinz-Weiß et al. (2022) reported an even smaller positive correlation ($r = 0.11$). As a positive activating emotion, enjoyment may facilitate comprehension through several pathways: by increasing engagement, sustaining attention, reducing cognitive fatigue, and promoting persistence during challenging passages (e.g., Goetz and Hall, 2013; Pekrun et al., 2007; Pekrun et al., 2017; Schoenherr et al., 2025).

Overall, the findings emphasize the importance of motivational and affective variables for text comprehension. The convergence of group comparisons and correlational results indicates that learners benefit most when they experience a strong sense of control. Moreover, although based on correlational analyses that do not establish causality, perceived value and enjoyment also appear to be associated with enhanced comprehension. Thus, learning environments should be designed to foster experiences of control, subjective value, and enjoyment to support learning from text.

Judgment accuracy

Concerning judgment accuracy in terms of bias (H2), no significant group differences were found. This suggests that an increased sense of control does not lead to more or less accurate judgments of one's text comprehension. As indicated previously, perceived control may primarily foster motivational and cognitive engagement, such as persistence, focused attention, and strategic learning behavior, which in turn support performance outcomes like text comprehension. However, it may not substantially promote metacognitive engagement, such as monitoring, and thus not improve judgment accuracy. In other words, while perceived control appears to drive cognitive engagement, it may have no or context-dependent effects on judgment accuracy.

The correlation analyses showed that students' judgment accuracy was not significantly associated with perceived value or enjoyment. In contrast, perceived control was negatively correlated with judgment accuracy, indicating that higher control was linked to slightly lower accuracy in predicting one's comprehension. Notably, as shown in Table 3, enjoyment and perceived value were significantly positively correlated with text comprehension, suggesting that they acted as valid cues for performance in the present study.

This pattern differs from Prinz-Weiß et al. (2022), where enjoyment was associated with overestimation without being a valid

cue for comprehension. In line with our findings, Prinz-Weiß et al. (2023) reported that achievement emotions (e.g., hope) were used as cues for predicting performance but were not directly associated with monitoring accuracy. These divergent results can be interpreted using the cue-utilization framework (Koriat, 1997), which posits that learners rely on multiple cues—affective, cognitive, and contextual—when making metacomprehension judgments. Depending on the task and context, cues such as enjoyment and perceived value may either support accurate judgments or, as in previous studies, contribute to overestimation.

Interestingly, students' judgments were generally quite accurate. This contrasts with previous findings (e.g., Maki et al., 2005) and may partly reflect central tendency bias, where learners tend to choose mid-range response options. In the present study, 40% of the students rated their performance in the mid-range (three out of six questions), which coincided with actual mid-range performance and may have produced accurate judgments.

Regulation effectiveness

There was no significant difference in regulation effectiveness between the experimental and control groups (H3). Thus, a higher sense of control did not influence the effectiveness of students' regulation processes. As noted earlier, perceived control may primarily enhance cognition and motivation rather than metacognition, and therefore may not translate into more effective regulation. This interpretation is supported by the finding that regulation time did not differ significantly between groups. Although the specific strategies students employed during rereading cannot be inferred, the comparable rereading times indicate that students' regulatory behavior was quite similar, likely preventing group differences in regulation effectiveness.

Despite their overall relatively accurate judgements, students' regulation was rather ineffective. This became evident from the lacking improvement in text comprehension observed in both groups after the regulation phase. This result stands in contrast to prior research that found that more accurate judgments of comprehension lead to more effective regulation (e.g., Dunlosky and Rawson, 2012; Thiede et al., 2003).

Several reasons might account for the low effectiveness of regulation observed in this study. One possible reason is a fatigue effect. Specifically, the regulation phase and retesting occurred at a relatively late stage of the study, which could have negatively impacted students' concentration and motivation. Moreover, participants' anonymity and the absence of performance feedback may have decreased the perceived value of engaging in regulatory activities, lowering students' effort.

Another possible explanation is related to the regulation strategy used in this study. More precisely, rereading is a commonly used strategy for regulating text comprehension and is intuitively accessible. However, compared to more elaborate strategies, such as concept mapping or self-explaining, it is less effective (e.g., Dunlosky, 2013; Redford et al., 2012; Prinz et al., 2020). Specifically, rereading may not sufficiently activate cognitive processes required for deep comprehension, such as elaboration, integration with prior knowledge, or monitoring of comprehension (e.g., Dunlosky, 2013), thereby limiting regulation effectiveness. Future studies should

systematically examine the impact of different regulation strategies and assess their effectiveness for self-regulated learning from text.

Nonetheless, the result that text comprehension did not significantly improve following the regulation phase aligns with previous literature highlighting the difficulties learners, and especially younger learners such as children and adolescents, face in self-regulation (e.g., Cheng et al., 2025; De Bruin and van Gog, 2012).

The correlation analyses revealed no significant relationships between regulation effectiveness and perceived value or enjoyment. Although positive achievement emotions such as enjoyment are theorized to support self-regulation by helping learners actively manage and control their own learning (e.g., Pekrun et al., 2002), the present findings indicate that enjoyment is not necessarily associated with more effective regulation. Moreover, a higher perceived value usually supports effort and strategic learning (e.g., Li, 2024). Perceived control was negatively associated with regulation effectiveness, although the effect was small. One possible explanation for why there was no association between perceived value and regulation effectiveness in this study is that students who placed higher value on the learning content experienced increased performance pressure or anxiety, which negatively affected their ability to regulate their learning effectively. This interpretation also aligns with expectancy-value theory (Eccles and Wigfield, 2002), which suggests that high subjective value, especially when combined with uncertainty about success, can elevate fear of failure and impair performance. Future research should explore the conditions under which perceived value helps or harms regulation.

A medium-sized positive correlation was observed between metacomprehension accuracy and regulation effectiveness. This result supports the central role of accurate metacomprehension for effective regulation: Learners who make more accurate judgments engage in more appropriate regulatory actions, resulting in improved text comprehension (e.g., Dunlosky and Rawson, 2012; Thiede et al., 2003). It should be noted, however, that the reported correlations reflect interindividual relationships, rather than intraindividual ones. Hence, these correlations do not necessarily imply that a learner's high metacomprehension accuracy would lead to more effective regulation.

Limitations and future research

A central limitation of the present study is that the intervention increased perceived control but failed to enhance perceived value and enjoyment. Future interventions should use more engaging materials, such as interactive videos or personal stories that present situations students can relate to emotionally and are relevant to their personal lives. Examples include videos or stories about local environmental issues (e.g., CO_2 emissions in their neighborhood). Moreover, instead of having students write a blog entry for the school homepage, tasks could be designed to connect with their personal interests and goals, such as writing a reflection on how the topic affects their own decisions and lives. Such materials might better highlight the relevance of the learning content, thereby increasing its subjective value and promoting enjoyment.

In the present study, enjoyment was assessed as a state emotion. We focused on state enjoyment because state emotions are more

susceptible to change and have previously been found to serve as cues for metacomprehension judgments (e.g., Prinz-Weiß et al., 2022). To gain a comprehensive perspective on emotional influences for self-regulated learning from text, future studies should also examine trait emotions.

Empirical findings indicate that interest plays a central role in the emergence of positive learning emotions, particularly enjoyment (e.g., Pekrun et al., 2002, 2007, 2011; Camacho-Morles et al., 2021). Interest may influence learners' emotional experience not only directly but also indirectly by increasing the subjective value of the content and enhancing learners' sense of control. Future work should systematically assess participants' interest in the learning content, for example, through questionnaires to measure situational or dispositional interest, to allow for a more detailed analysis of the underlying mechanisms.

A further methodological limitation relates to the reliance on self-report measures for assessing perceived control, perceived value, and enjoyment, which are prone to biases such as social desirability. Future studies should therefore complement self-reports with behavioral or physiological measures (e.g., time-on-task for perceived value and control; heart rate variability or skin conductance as indicators of enjoyment) to obtain more objective and reliable assessments of these constructs.

In addition, the study employed only a single type of text, namely expository text, which restricts the generalizability of the findings to other learning material. Subsequent research should therefore include other text types, such as narrative or persuasive texts, to determine to what extent the observed effects generalize across different text types.

As the present study included only a single measurement time point, no conclusions can be drawn about long-term effects of the interventions. Longitudinal or repeated-measures designs are recommended to examine sustained effects over time.

A final imitation to consider is that, while previous research (Prinz-Weiß et al., 2022) reported small to moderate effect sizes, this study observed predominantly small effects. This suggests that future investigations should anticipate small effect sizes and employ larger sample sizes to ensure that effects can be reliably detected and further explored.

Practical implications

For educational practice, the findings suggest that teachers should actively foster students' perceived control to support their comprehension when learning from text. As noted earlier in the Discussion, students can be supported through motivating statements about effort and growth such as, "Everyone can master the learning content with effort, just as muscles grow with exercise" (e.g., Morra and Borella, 2015). Additionally, providing choices in learning activities and clear task structures can help increase students' perceived control over the learning process (e.g., Pekrun et al., 2007).

Moreover, the findings, although correlational, support that students' perceived value of the learning content as well as their enjoyment should be strengthened to potentially enhance their text comprehension. For example, teachers could enhance students' perceived value by clearly communicating the importance of acquiring the knowledge or by allowing students to identify for themselves how the content is relevant to their own goals or experiences (e.g., Pekrun et al., 2007). The suggested means to enhance perceived control and value can also raise students' enjoyment. Moreover, enjoyment is an educational goal in its own right, as positive emotional experiences contribute to students' overall well-being.

Conclusion

Although the intervention used in this study did not significantly increase enjoyment, it successfully enhanced learners' perceived control over mastering the content. This increase in perceived control was associated with improved text comprehension, highlighting perceived control as an important motivational factor when learning from texts. No significant differences were found for metacomprehension accuracy or regulation effectiveness.

The exploratory correlational analyses yielded additional insights. Enjoyment was positively associated with text comprehension before and after regulation. However, enjoyment was not significantly related to metacomprehension accuracy or regulation effectiveness. This suggests that, in the present study, enjoyment may have mainly supported cognitive processes that enhanced comprehension, rather than metacognitive processes. It should be noted that these correlational findings do not provide evidence of causality. Therefore, further intervention studies are needed that effectively manipulate enjoyment to clarify the direction and causal nature of these relationships.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/qsej4/files/osfstorage/688b 70b52542bb1433234104.

Ethics statement

The studies involving humans were approved by Ethics Committee at the University of Education Karlsruhe. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

CS: Writing – original draft, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration. AP-W: Writing – review & editing, Conceptualization.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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