

Collaborative and Individual Mind Mapping in Online EFL Writing: Effects on Engagement and Writing Anxiety

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Article Info	Abstract
Article type: Research Article Article history: Received May 20, 2026 Received in revised form September 18, 2026 Accepted September 26, 2026 Published online September 30, 2026 Keywords: Mind mapping, Engagement, Writing anxiety, Grit, Quantitative	Pre-writing digital interventions have increasingly gained prominence in online second/foreign language (L2) writing pedagogy, yet their interplay with individual learner traits remains underexplored. This study examined the effects of two types of computer-assisted pre-writing planning—collaborative and individual mind mapping—on high- and low-grit Iranian L2 learners' cognitive engagement, behavioral engagement, and writing anxiety in online writing classes. 45 university students at Shahrekord University were recruited from three intact classes and assigned to collaborative mind mapping ($n=15$), individual mind mapping ($n=15$), and traditional control ($n=15$) groups. Each group included high- and low-grit learners and participated in online instructional sessions. Cognitive engagement was assessed through complexity, accuracy, and fluency of argumentative writing tasks completed in pretest and posttest phases. Behavioral engagement was measured by counting the number of ideas generated during pre-writing activities. Writing anxiety and grit were assessed using Cheng's (2004) writing anxiety scale and Duckworth et al.'s (2007) Grit Scale, respectively. Mixed-design analyses of variance revealed that collaborative digital mind mapping resulted in significantly higher behavioral engagement and reduced writing anxiety, alongside moderate gains in syntactic complexity and fluency compared with the individual and control conditions. However, grit failed to significantly moderate the intervention's effects across engagement and anxiety indices, demonstrating only a main effect on fluency. These findings from a single-institution cohort indicate that collaborative mind mapping provides pre-writing support regardless of L2 learners' dispositional perseverance, suggesting instructors can implement collaborative digital mapping without tailoring tasks to individual grit levels.

Cite this article: Roohani, A., Eslamian, S., & Cheraghi Chaleshtari, R. (2026). Collaborative and Individual Mind Mapping in Online EFL Writing: Effects on Engagement and Writing Anxiety. *Technology Assisted Language Education*, 4(3), 132-156. doi: 10.22126/tale.2026.13725.1177



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Publisher: Razi University.

DOI: <http://doi.org/10.22126/tale.2026.13725.1177>

Introduction

Pre-writing planning is universally acknowledged as an indispensable phase in the process of language teaching and learning that promotes optimal second/foreign language (L2) writing (Ellis, 2021). According to the cognitive load theory, systematic pre-task planning helps the learners unload their limited working memory in terms of separating concept generation from language processing in sentence production and grammar checks. With computer-assisted language learning (CALL) gaining widespread acceptance as a means of language learning, pre-writing planning has been transformed from a linear outline into digital multimodal tools where thought processes are externalized (Buran & Filyukov, 2015; Warschauer & Grimes, 2007).

These technologies include computer-assisted mind mapping (Buzan, 2006), which has become popular for strategic planning in writing. In fact, the representation of conceptual knowledge through a spatial hierarchy helps mind mapping technology to organize ideas in a way that allows for the better cognitive retrievability and logic (Davies, 2011; Farrand et al., 2002). A number of studies also support the impact of mind mapping on the L2 writing proficiency, specifically on syntax and grammar, as well as lexical diversity (Al-Jarf, 2009; Bukhari, 2016; D'Antoni et al., 2010).

Nonetheless, there are two major gaps. First, whereas most of the research has focused on the final products of the tasks performed, relatively little emphasis has been put on the affective and multidimensional engagement processes involved in task preparation, especially within online classrooms where learner isolation and writing anxiety are common (Aubrey, 2022; Yu & Zhou, 2022; Zhou et al., 2022). Second, previous research has generally failed to recognize the functional difference between solitary and collaborative online mind mapping. According to Vygotsky's (1978) sociocultural theory, learning develops through social interaction and the use of cultural tools. In this context, a collaborative mind mapping platform can support peer scaffolding and knowledge construction by allowing learners to share, discuss, and refine each other's ideas during the idea-generation stage. The collaborative visual medium can reduce writing anxiety by diffusing the cognitive load and normalizing the idea negotiation process, while at the same time increasing behavioral engagement (task commitment) and cognitive engagement (linguistic form processing). Solitary mind mapping, on the other hand, entails self-regulation without any help, which can be cognitively demanding.

Moreover, the degree to which these planning strategies are used may be moderated by the personal non-cognitive attributes of the learner, specifically grit, which is perseverance and passion for long-term goals (Duckworth et al., 2007). For computer-mediated collaborative planning, there is a need for persistence because L2 learners have to work with different opinions from peers, interact with computer interfaces, and deal with structural conflicts before writing. High levels of grit will make L2 learners more capable of maintaining persistence when facing such complex social processes, while low levels of grit may make L2 learners overwhelmed and give up on the task. On the other hand, the distributed nature of the

collaborative map may provide low-grit learners with an external social structure that helps them maintain persistence, while individual planning may cause them to quit too early.

Previous research has examined computer-supported cooperative pre-writing (Lan et al., 2015), collaborative L2 writing (Storch, 2013), and engagement in technology-supported writing activities (Z. V. Zhang & Hyland, 2018). More recently, Peng et al. (2022) demonstrated that the design of group-awareness tools influenced L2 learners' engagement in online collaborative writing. However, these studies leave room for a more focused comparison of collaborative mind mapping, individual mind mapping, and no mapping (traditional outlining) during the pre-writing stage, particularly in online L2 writing classes.

Additionally, it is important to investigate whether L2 learners with different grit levels respond similarly to these planning conditions. Although grit has been associated with academic engagement and L2 writing achievement (Hodge et al., 2018; J. Zhang, 2023), its potential role in shaping L2 learners' responses to different computer-assisted pre-writing activities remains insufficiently understood. Further research is needed to establish how these planning conditions affect writing anxiety alongside cognitive and behavioral engagement. To address these issues, the present study examined the effects of collaborative mind mapping, individual mind mapping, and no mapping on cognitive engagement, behavioral engagement, and writing anxiety among high- and low-grit Iranian English as a foreign language (EFL) learners in online L2 writing classes. In doing so, it sought to clarify how different planning approaches could support L2 learners with varying levels of grit. The current research endeavored to fill the aforementioned empirical and theoretical gaps by investigating how computer-assisted collaborative mind mapping, in contrast to individual mind mapping and traditional outlining (no mind mapping), impacts L2 learners' cognitive engagement, behavioral engagement, and writing anxiety in an online instructional setting. The study additionally sought to examine whether grit, as a dispositional variable, had a moderating effect on the aforementioned pedagogical factors. The present study was guided by the following research questions:

To what extent do different types of computer-assisted pre-writing planning (i.e., collaborative mind mapping, individual mind mapping, and no mapping) have an effect on high- and low-grit Iranian L2 learners' degree of cognitive engagement in online L2 writing classes?

To what extent do different types of computer-assisted pre-writing planning (i.e., collaborative mind mapping, individual mind mapping, and no mapping) have an effect on high- and low-grit Iranian L2 learners' degree of behavioral engagement in online L2 writing classes?

Do different types of computer-assisted mind mapping differ in terms of their impact on high- and low-grit Iranian L2 learners' writing anxiety?

Literature review

Computer-mediated Collaborative Writing

English written format, in the recent era, has become the most widely used medium for international communication. For L2 learners, it serves as a crucial academic skill, allowing them to articulate complex ideas. However, achieving competence in this skill often presents challenges to L2 learners because it requires mastery of various linguistic aspects such as vocabulary, grammar, and spelling (Tuan & Nga, 2022). One interactive approach introduced to mitigate these difficulties is collaborative writing (Baker, 2013). This method encourages L2 learners to participate in the writing process by discussing both form and content and co-constructing ideas, which ultimately leads to the production of a shared text (Storch, 2013). In other words, collaborative writing refers to any form of collaboration among L2 learners in decision-making or negotiation to produce a written output (Storch, 2013).

The advent of Web 2.0 has fostered the development of computer-mediated collaborative writing (CMCW), a promising area of research within writing pedagogy (Li, 2018). CMCW provides L2 learners with multiple opportunities to develop writing autonomy and offers spatial and temporal flexibility (Amiryousefi, 2017). Furthermore, digital platforms allow L2 teachers to readily monitor student progress and provide feedback remotely (Bikowski & Vithanage, 2016). Research has explored the impact of CMCW on various aspects, including L2 learners' identity (Chen et al., 2022), verbal and on-screen peer interaction (Cheung, 2022), task modality and complexity (Hsu, 2024), mediating interactional factors (Cho, 2017), and perceptions and attitudes (Wang, 2015).

Regarding identity, Chen et al. (2022) demonstrated that both individual and contextual factors influenced L2 learners' identity construction within blended learning environments designed for collaborative writing. Cheung (2022) found that pairs focused more on textual elements than multimodal factors during writing tasks. Conversely, Hsu (2022) investigated the impact of two task modalities on attention to form and peer interaction. Results indicated that modality significantly affected both the frequency and quality of attention to form, as well as peer interaction patterns. Cho (2017) argues that individual performance in collaborative writing can vary due to mediating factors such as task representations, the congruence between self-perceived and other-perceived roles, perceptions of peer feedback, and modes of communication. As for L2 learners' attitudes toward CMCW, Wang (2015) illustrated that Wiki platforms could promote a positive attitude towards writing, in addition to enhancing business writing skills through collaborative work.

Collaboration in all stages of writing, from planning and drafting to revising, is well established (Storch, 2013). However, existing research has largely neglected the impact of collaborative writing specifically during the planning phase (Lan et al., 2015; Amiryousefi, 2017). Also, how collaborative planning influences L2 learners' engagement remains insufficiently explored, necessitating further research.

Engagement

The concept of learning engagement has become a central theme in educational research over the past few decades (Hiver et al., 2020). Despite broad agreement that engagement is crucial for effective learning, scholars in L2 education have defined it differently, reflecting varied perspectives on what counts as engagement and how it should be measured (Appleton et al., 2008; Sulis, 2022). One widely adopted framework is that of Fredricks et al. (2004), who identified three interrelated dimensions of learning engagement: behavioral, cognitive, and emotional engagement.

Behavioral engagement generally refers to students' visible participation and effort in learning activities. L2 learners are regarded behaviorally engaged when attending classes regularly, staying focused during lessons, and actively taking part in tasks (Philp & Duchesne, 2016). This dimension of engagement is considered vital, because it has been linked to positive academic outcomes, such as improved performance and reduced dropout rates (Fredricks et al., 2004). Cognitive engagement involves the active mental investment L2 learners make in their learning. It refers to the depth of processing and thoughtful application of self-regulation strategies to comprehend complex concepts and develop skills (Fredricks et al., 2004; Fredricks & McColskey, 2012). Finally, emotional engagement captures the affective dimension of learning, encompassing L2 learners' positive and negative feelings, reactions, and attitudes towards the academic environment and its various elements, such as instructors, learning materials, and the overall learning context (Fredricks & McColskey, 2012).

As a concept still gaining traction in educational psychology (Philp, 2016), learning engagement has become a central focus in numerous studies, particularly within L2 learning. Researchers have explored the interplay between learning engagement and a variety of factors in L2 learning. For instance, the impact of L2 teachers' feedback on L2 learners' engagement in L2 writing has been investigated (Hyland, 2003; Z. V. Zhang & Hyland, 2018), with studies examining how feedback styles can either promote or hinder engagement. Similarly, the role of peer feedback in relation to L2 writing engagement has been explored (Fan & Xu, 2020), highlighting the potentially divergent effects of different types of peer feedback. Furthermore, the evolving role of artificial intelligence (AI) in education has prompted research into how AI-integrated instruction affects foreign language L2 learners' engagement (Guo & Wang, 2025). Investigations have also been conducted on the role of learning engagement in shaping language use within collaborative writing tasks (B. Zhang, 2025).

Specifically, Z. V. Zhang and Hyland (2018) found that engagement could act as a critical mediating factor in determining the extent to which L2 learners benefit from feedback and its subsequent impact on their writing development. Expanding on this issue, research by Fan and Xu (2020) on peer feedback revealed that the type of feedback significantly influenced the nature of student engagement. Form-focused peer feedback generally fostered higher levels of positive affective, cognitive, and behavioral engagement, whereas content-focused feedback led to decreased cognitive and behavioral engagement. Guo and Wang's (2025) study into AI's influence on student engagement and emotions in L2 contexts revealed that AI-integrated

instruction positively affected L2 learners' cognitive, emotional, and social engagement. Their findings also highlighted the complexities of L2 learners' emotional experiences, and their subsequent impact on overall learning engagement. Regarding collaborative writing, B. Zhang (2025) determined that active participation by Russian L2 learners in collaborative writing resulted in more focused attention to grammatical errors, whereas socially withdrawn or less enthusiastic L2 learners were prone to neglecting language issues they encountered. However, a significant limitation of the existing research is that the majority of the studies have focused on L2 learners' writing engagement within face-to-face learning environments, not the online environment. That is, the lack of studies investigating strategies and practices that effectively promote higher writing engagement, specifically in online environments, represents a significant gap in our understanding (Peng et al., 2022).

Grit

Grit is a non-cognitive personality trait characterized by perseverance and passion for long-term goals (Duckworth et al., 2007). Rather than emphasizing intellectual ability or talent, grit highlights the importance of sustained effort and commitment when facing challenges. Duckworth et al. (2007) identified two dimensions of grit: consistency of interest (CI), which refers to maintaining long-term interests, and perseverance of effort (PE), which involves continuing to work toward goals despite difficulties. Although both dimensions are central to the concept of grit, perseverance of effort has shown stronger associations with academic achievement (Credé et al., 2017). This distinction is particularly relevant to L2 learning, where developing language skills often requires sustained practice and persistence through difficulties.

Previous studies have explored the relationship between grit and several educational and psychological factors, including growth mindset (Park et al., 2020), academic burnout and perfectionism (Liu et al., 2021), academic engagement and achievement (Hodge et al., 2018; Wolters & Hussain, 2015), and L2 writing achievement (J. Zhang, 2023). For example, Hodge et al. (2018) examined the contribution of grit to university students' academic engagement and outcomes, while J. Zhang (2023) investigated its relationship with L2 writing achievement. These studies suggest that grit may be relevant to learners' academic experiences, although its influence may differ depending on the demands of particular learning activities.

Writing Anxiety

Writing anxiety can affect learners' confidence, effort, and overall writing performance (Cheng, 2002; Woodrow, 2011). In support of this issue, Cheng (2002) found that learners' perceptions of their writing competence were closely associated with writing anxiety. Woodrow (2011) also reported an association between writing anxiety and lower levels of effort. One way to reduce writing anxiety, according to Zarrinabadi and Rezazadeh (2020) is by giving feedbacks and comments on the L2 writing goals, because they help L2 learners to have a sense of accomplishment and follow to the next stage.

Furthermore, writing anxiety may influence how L2 learners approach writing tasks. Cognitively, anxious L2 learners may experience worry and negative expectations about their writing ability, while behaviorally, they may be reluctant to participate or avoid writing activities altogether (Cheng, 2004). This avoidance behavior, in particular, due to writing anxiety in online classes is observed among learners (Salem, 2022). It is reported that collaborative writing can encourage L2 learners to participate in the writing process because it offers opportunities for interaction and mutual support (Storch, 2013), which may, ultimately, reduce the writing anxiety the L2 learners experience.

The present study draws on sociocultural theory (Vygotsky, 1978; Lantolf & Thorne, 2006) and the multidimensional framework of engagement (Fredricks et al., 2004) to examine how computer-assisted pre-writing activities may influence L2 learners' engagement and writing anxiety. From a sociocultural perspective, cognitive development is mediated by social interaction and cultural tools, particularly language (Vygotsky, 1978; Lantolf & Thorne, 2006). Swain (2000) has emphasized the role of collaborative dialogue in helping learners exchange ideas, negotiate meaning, and work through language-related difficulties. Similarly, Storch (2013) has highlighted the learning opportunities offered by collaborative L2 writing. In collaborative mind mapping, a shared visual space may support these processes by allowing learners to develop and organize ideas together.

The current study also draws on Fredricks et al.'s (2004) multidimensional framework of engagement, which has application for L2 learning tasks (Philp & Duchesne, 2016). Although engagement includes three interconnected dimensions, the present study focuses specifically on behavioral and cognitive engagement because they are more directly aligned with how L2 learners participate in and mentally engage with computer-assisted pre-writing activities. Behavioral engagement captures learners' involvement in planning tasks, while cognitive engagement reflects the effort and strategic thinking involved in generating, evaluating, and organizing ideas. Emotional engagement is acknowledged as an important dimension but is not measured separately. Instead, writing anxiety is examined as a distinct writing-related affective construct (Cheng, 2004). Furthermore, learners differ in traits like grit; thus, in this multidimensional framework, Fredricks et al.'s (2004), it is useful to capture the complexity of their engagement. In fact, L2 learners with higher grit may be more willing to persist through collaborative negotiation or independent planning, while those with lower grit may respond differently to peer support and visual scaffolding (Duckworth et al., 2007). Together, these perspectives provide a rationale for examining whether the effects of planning conditions on engagement and writing anxiety differ across grit levels.

Method

Design

This research study employed a quasi-experimental pretest/posttest comparison-group design. The participants were drawn from intact online English classes, which were randomly assigned

at the cohort level to one of three treatment groups: collaborative digital mind mapping ($n = 15$), individual digital mind mapping ($n = 15$), or control ($n = 15$). The pre-writing planning condition and grit—with grit being divided into high and low categories—were the independent variables, while the dependent variables consisted of cognitive engagement (as measured by writing complexity, accuracy, and fluency), behavioral engagement (in the form of idea generation during the pre-writing stage), and L2 writing anxiety. Because of the quasi-experimental pretest/posttest approach, it was possible to look at the interaction between the pre-writing planning condition and grit level as it related to learner engagement and L2 writing anxiety.

Participants

The participants were 45 Iranian adult L2 learners, both male and female, enrolled in an online academic writing course offered by Shahrekord University in 2025. Inclusion criteria required participants to attend all instructional and testing sessions, complete all assessment batteries, and demonstrate acceptable general English proficiency. Language proficiency was verified prior to the intervention using the Oxford Placement Test (OPT; Allan, 2004), on which all participants obtained scores corresponding to the B2 level on the Common European Framework of Reference (CEFR). Comprehensive demographic characteristics of the participants across the three instructional conditions are summarized in Table 1.

Table 1

Demographic Characteristics of the Participants Across Instructional Conditions

Characteristic	Collaborative	Individual	Control	Total
Age Mean (<i>SD</i>)	21.40 (2.12)	21.80 (2.45)	21.20 (1.98)	21.47 (2.16)
Age Range	19–26	19–27	18–25	18–27
Gender, <i>n</i> (%) - Female	9 (60.0%)	10 (66.7%)	9 (60.0%)	28 (62.2%)
Gender, <i>n</i> (%) - Male	6 (40.0%)	5 (33.3%)	6 (40.0%)	17 (37.8%)
Undergraduate English majors	11 (73.3%)	10 (66.7%)	12 (80.0%)	33 (73.3%)
Non-English Majors	4 (26.7%)	5 (33.3%)	3 (20.0%)	12 (26.7%)
Nationality	Iranian (100%)	Iranian (100%)	Iranian (100%)	Iranian (100%)
L1 Background	Persian	Persian	Persian	Persian
OPT Mean (<i>SD</i>)	68.40 (4.12)	67.80 (4.50)	68.10 (3.95)	68.10 (4.15)
CEFR Equivalent	B2	B2	B2	B2

Note. OPT = Oxford Placement Test (standard 120-point scale; B2 range corresponds to scores 61–80).

Instruments

Grit Scale (GS)

General grit was measured using the Grit Scale (12 items; Duckworth et al., 2007). This test measures two basic aspects of grit on a 5-point Likert scale (1 = not at all like me to 5 = very much like me): consistency of interest (6 items) and perseverance of effort (6 items).

Completion of the test took about 10 minutes. Construct and predictive validity have been well established in the educational literature (Credé et al., 2017; Duckworth et al., 2007). Content validity and cultural relevance of the test were checked by an expert panel consisting of two associate professors of applied linguistics and two EFL lecturers. Reliability was supported by Cronbach's alpha ($\alpha = .81$), which was above the conventional .70 benchmark. Following the scale's theoretical midpoint of 3.00, participants were classified as low grit if their scores were ≤ 3.00 and high grit if their scores were > 3.00 . This categorization yielded 23 L2 learners in the low-grit subgroup and 22 learners in the high-grit subgroup across the whole sample.

Writing Anxiety Scale (WAS)

L2 writing anxiety was measured using the Writing Anxiety Inventory (Cheng, 2004). The scale includes 22 items measuring three components: somatic anxiety, cognitive anxiety, and avoidance behavior. It is a five-point Likert scale in which 1 denotes "strongly disagree" and 5 denotes "strongly agree." Construct validity of the scale was examined through confirmatory factor analysis (CFA) by Cheng (2004). Content appropriateness and cultural relevance were reviewed by the same academic panel. The scale demonstrated high internal consistency in the present study (Cronbach's alpha, $\alpha = .84$), consistent with the reliability coefficients reported by Cheng (2004).

Cognitive and Behavioral Engagement Measure

Cognitive engagement was operationalized using multidimensional text-based measures of complexity, accuracy, and fluency (CAF; Mohammadi et al., 2024; Wigglesworth & Storch, 2009). These measures were derived from participants' argumentative essays written at pretest and posttest. Fluency was measured by the total number of words produced within the allotted time. Syntactic complexity was assessed using mean length of T-units (MLT) and the ratio of dependent clauses to total clauses (DC/C). Accuracy was measured using the ratio of error-free clauses to total clauses (EFC/C) and the number of linguistic errors per 100 words. To assess coding reliability, two independent applied linguistics raters coded a randomly selected 25% of the written corpus. Interrater reliability was assessed using Cohen's kappa for the identification of syntactic units ($\kappa = .98$) and the intraclass correlation coefficient for error identification (ICC = .92). These values indicated excellent interrater agreement. After interrater reliability was calculated, discrepancies were resolved through discussion between the raters.

Behavioral engagement was operationalized as active task ideation, measured by the total number of distinct, relevant ideas generated on a structured pre-writing worksheet (adapted from Johnson et al., 2012; see Appendix) completed during the designated 15-minute planning phase prior to essay composition (Mohammadi et al., 2024). Two independent raters coded idea units; interrater agreement reached an ICC of .90.

Procedure

The program ran for 15 sessions held twice a week during the school term. Instruction was delivered via Adobe Connect platform, , each lasting approximately 120 minutes. There were 13 teaching sessions, each about 120 minutes long adding, up to 26 hours of instruction total. The class used *Longman Academic Writing Series 4: Essays*. This book was picked because it moves step by step from writing paragraphs to full argumentative essays. That structure aligns with a B2-level course. The current study included different phases.

Pretest Phase (Session 1). The participants first completed the OPT, GS, and SLWAS batteries. Next, they completed Part A of the writing worksheet (15 minutes) by listing distinct ideas for an argumentative prompt (see Appendix) Subsequently, they were allotted 40 minutes to compose a full argumentative essay (Part B; see Appendix). Following baseline testing, intact classes were assigned to the three treatment conditions.

Instructional Intervention Phase (Sessions 2–14). Students attended classes twice a week over the 15-session course. Sessions 1 and 15 were used for the pretest and posttest, respectively. Instruction was provided in the 13 sessions between the two tests. Each instructional session lasted approximately 120 minutes and was delivered using Adobe Connect. *Longman Academic Writing Series 4* was used as the instructional textbook, and the same instructor (a female teacher who was a PhD student in English language teaching) provided instruction using the textbook chapters in each session for all groups; hence, all groups received the same genre-based instruction, writing models, and linguistic input. The only difference was the planning strategy used prior to writing.

The three classes were randomly assigned to one of three groups ($n = 15$ per group). In the collaborative mind mapping group, the participants collaboratively created digital mind maps using MindMeister to plan their writings over every session of their course. Before every session the teacher made a new mind map template on the MindMeister with the related topics of their textbook, intended to be covered on each session and sent the link to the students' email address at the start of each session. Then, they joined the link when the teacher asked them to see their classmates' ideas, add new ideas to it, revise it and make comments on it. Figure 1 shows the screenshots of a mind map constructed collaboratively by the L2 learners during one session. The map allowed them to make a variety of comments.

Figure 1

Screenshots of the L2 Learners' Mind Mapping on MindMeister



Alt Text: Two Screenshots of Mind Mapping Constructed Collaboratively by the L2 Learners in the Collaborative Mind Mapping Group

On the other hand, the individual mind mapping group developed their digital mind maps individually. The L2 learners in this group had access to individual MindMeister workspaces via separate links and responded to the same topic prompts but without any access to peer maps. Lastly, the control group used conventional pre-writing instructional method. In the 15-minute planning stage, these L2 learners performed solo brainstorming and outlining using traditional methods like word processors or paper, without access to digital mind mapping software/platform or peer collaboration.

Posttest Phase (Session 15). In the final session, the L2 learners retook the SLWAS to evaluate shifts in writing anxiety. Under identical testing conditions, they completed the pre-writing idea generation worksheet followed by the posttest argumentative essay. To ensure prompt comparability across testing intervals, prompt topics were counterbalanced and validated for parallel cognitive difficulty by the expert panel.

Data Analysis

Statistical analysis was done using IBM SPSS Statistics (Version 26). In order to validate the assumptions prior to conducting inferential analysis, normality of distribution was checked through Shapiro-Wilk test ($p > .05$) as well as checking for skewness and kurtosis, which was well below the accepted value of ± 1.5 . Homogeneity of variance was tested using Levene’s test ($p > .05$). Since the within-subjects factor Time had only two levels (pretest vs. posttest), the assumption of sphericity was naturally met.

Three-way $2 \times 3 \times 2$ mixed-design analyses of variances (ANOVAs) were conducted on cognitive engagement, behavioral engagement, and writing anxiety. In the analyses, ‘Time’ (Pretest vs. Posttest) was the within-subjects factor, while ‘Planning Condition’ (Collaborative Mind Mapping, Individual Mind Mapping, Control) and ‘Grit Level’ (High vs. Low) were the between-subjects factors. Where there was an effect of a meaningful nature, a post hoc analysis using Bonferroni correction was performed on a pairwise comparison basis. In other words, a Bonferroni correction was applied to reduce the risk of Type I errors when conducting multiple univariate tests. The effect size for each measure of interest was obtained through partial eta squared (η^2_p) and evaluated against Cohen's criteria (1988) of small (.01), medium (.06), and large (.14).

Prior to the beginning of the study every person involved was told about the boundaries of the research. They were also informed about the data safety steps that the organization and reminded that they can leave the study anytime. The forms for agreeing to take part were signed using a computer. All the test scores, written assignments and records of activity, on the website were given codes. Kept on secure drives. This was done to protect their privacy and keep their identities hidden.

Results

Preliminary analyses included the calculation of descriptive statistics, followed by one-way between-groups ANOVA to check baseline equality among the groups. Table 2 summarizes the descriptive statistics, and Table 3 presents the ANOVA results.

Table 2

Descriptive Statistics for Baseline Writing Pretest Scores Across Groups

Group	<i>N</i>	<i>M</i>	<i>SD</i>	<i>SE</i>	95% CI [LL, UL]	Min	Max
Collaborative	15	64.80	3.14	0.81	[63.06, 66.54]	61	69
Individual	15	64.47	3.80	0.98	[62.36, 66.57]	60	69
Control	15	63.93	2.79	0.72	[62.39, 65.48]	60	69
Total	45	64.40	3.22	0.48	[63.43, 65.37]	60	69

Note. CI = confidence interval; LL = lower limit; UL = upper limit.

Table 3

One-Way ANOVA for Baseline Writing Pretest Equivalence

Source	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Between Groups	5.73	2	2.87	0.27	.766
Within Groups	449.07	42	10.69		
Total	454.80	44			

As indicated in Table 3, the one-way ANOVA yielded no statistically significant difference among the three groups in initial writing performance, $F(2, 42) = 0.27, p = .766$. This indicates that the groups did not differ significantly in baseline writing scores before the instructional intervention.

The first research question addressed whether planning condition and grit level significantly affected the L2 learners' cognitive engagement from pretest to posttest. A 2 (Time: pretest vs. Posttest) $\times$ 3 (Group: individual, control) $\times$ 2 (Grit: high vs. Low) three-way mixed-design ANOVA was run. Table 4 shows the statistics, for each condition and grit subgroup. Table 5 includes the within-subjects effects for cognitive engagement in the mixed-design ANOVA.

Table 4

Descriptive Statistics for Cognitive Engagement by Group, Grit Level, and Time

Group	Grit Level	<i>n</i>	Pretest <i>M</i> (<i>SD</i>)	Posttest <i>M</i> (<i>SD</i>)	Total <i>M</i> (<i>SD</i>)
Collaborative	High Grit	8	4.73 (0.17)	4.88 (0.06)	4.80 (0.11)
	Low Grit	7	4.77 (0.11)	4.88 (0.05)	4.82 (0.08)
	Total	15	4.75 (0.14)	4.88 (0.05)	4.81 (0.10)
Individual	High Grit	6	4.01 (0.29)	4.36 (0.31)	4.18 (0.30)
	Low Grit	9	4.23 (0.15)	4.60 (0.18)	4.42 (0.17)
	Total	15	4.14 (0.24)	4.50 (0.26)	4.32 (0.25)
Control	High Grit	8	2.98 (0.29)	3.05 (0.27)	3.01 (0.28)
	Low Grit	7	3.17 (0.11)	3.26 (0.12)	3.21 (0.12)

Group	Grit Level	n	Pretest M (SD)	Posttest M (SD)	Total M (SD)
Total Sample	Total	15	3.07 (0.24)	3.14 (0.23)	3.11 (0.24)
	High Grit	22	3.90 (0.80)	4.07 (0.85)	3.98 (0.83)
	Low Grit	23	4.07 (0.67)	4.28 (0.71)	4.17 (0.69)
	Total	45	3.99 (0.73)	4.18 (0.78)	4.08 (0.76)

Table 5*Repeated-Measures ANOVA Results for Cognitive Engagement*

Source	SS	df	MS	F	p	η^2_p
Time	0.78	1	0.78	181.58	< .001	.823
Time $\times$ Group	0.33	2	0.17	38.46	< .001	.664
Time $\times$ Grit	< 0.01	1	< 0.01	0.002	.962	< .001
Time $\times$ Group $\times$ Grit	0.01	2	< 0.01	0.78	.468	.038
Error (Time)	0.17	39	0.004			

As shown in Table 5, there was an effect of time $F(1, 39) = 181.58, p < .001, \eta^2_p = .823$ which means that cognitive engagement went up from the beginning test to the end test. The effect of time and group together was also large, $F(2, 39) = 38.46, p < .001, \eta^2_p = .664$, which means the way cognitive engagement changed was different for each condition. But the effect of time and grit together, $F(1, 39) = 0.002, p = .962, \eta^2_p < .001$, and the effect of time, group and grit together, $F(2, 39) = 0.78, p = .468, \eta^2_p = .038$, were not big enough in the analysis. To look at the differences between the Bonferroni-adjusted comparisons were employed (see Table 6).

Table 6*Bonferroni Post Hoc Multiple Comparisons for Cognitive Engagement Across Groups*

(I) Group	(J) Group	Mean Difference (I - J)	SE	p	95% CI [LL, UL]
Collaborative	Individual	0.49*	0.07	< .001	[0.32, 0.66]
	Control	1.71*	0.07	< .001	[1.54, 1.88]
Individual	Control	1.22*	0.07	< .001	[1.05, 1.39]

Note: *The mean difference is significant at the adjusted alpha level

Pairwise comparisons indicated that the collaborative group demonstrated significantly higher overall cognitive engagement than both the individual ($MD = 0.49, p < .001$) and control groups ($MD = 1.71, p < .001$). Furthermore, the individual group outperformed the control condition

($MD = 1.22, p < .001$). Subgroup comparisons across grit classifications (see Table 4) showed that learners in the collaborative group exhibited the highest posttest cognitive engagement regardless of grit profile (high grit: $M = 4.88$; low grit: $M = 4.88$).

The second research question examined the extent to which instructional planning conditions and grit levels affected the L2 learners' behavioral engagement across time. To address this question, a three-way mixed-design ANOVA was conducted on behavioral engagement scores. Table 7 presents the descriptive statistics of behavioral engagement in the three group and across grit levels, and Tables 8 and Table 9 report the results of inferential statistics, including the results of repeated-measures ANOVA and post hoc test comparisons, respectively.

Table 7

Descriptive Statistics for Behavioral Engagement by Group, Grit Level, and Time

Group	Grit Level	<i>n</i>	Pretest <i>M</i> (<i>SD</i>)	Posttest <i>M</i> (<i>SD</i>)	Total <i>M</i> (<i>SD</i>)
Collaborative	High Grit	8	4.69 (0.14)	4.87 (0.04)	4.78 (0.09)
	Low Grit	7	4.68 (0.14)	4.86 (0.04)	4.77 (0.09)
	<i>Total</i>	15	4.69 (0.14)	4.86 (0.04)	4.78 (0.09)
Individual	High Grit	6	3.95 (0.18)	4.30 (0.16)	4.13 (0.17)
	Low Grit	9	3.94 (0.29)	4.31 (0.25)	4.12 (0.27)
	<i>Total</i>	15	3.94 (0.24)	4.30 (0.21)	4.12 (0.23)
Control	High Grit	8	2.87 (0.22)	2.93 (0.23)	2.90 (0.23)
	Low Grit	7	2.84 (0.24)	2.93 (0.23)	2.89 (0.24)
	<i>Total</i>	15	2.86 (0.22)	2.93 (0.22)	2.89 (0.22)
Total Sample	High Grit	22	3.83 (0.82)	4.01 (0.88)	3.92 (0.85)
	Low Grit	23	3.83 (0.77)	4.06 (0.82)	3.95 (0.80)
	<i>Total</i>	45	3.83 (0.79)	4.03 (0.84)	3.93 (0.82)

Table 8

Repeated-Measures ANOVA Within-Subjects Effects for Behavioral Engagement

Source	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>	η^2_p
Time	0.91	1	0.91	173.89	< .001	.817
Time $\times$ Group	0.30	2	0.15	28.57	< .001	.594
Time $\times$ Grit	< 0.01	1	< 0.01	0.28	.601	.007
Time $\times$ Group $\times$ Grit	< 0.01	2	< 0.01	0.05	.949	.003
Error (Time)	0.21	39	0.005			

Repeated-measures ANOVA results in Table 8 showed a main effect of time, $F(1\ 39) = 173.89$, $p < .001$ $\eta^2p = .817$, and a significant Time $\times$ Group interaction, $F(2\ 39) = 28.57$, $p < .001$, $\eta^2p = .594$. However, the Time $\times$ Grit interaction, $F(1\ 39) = 0.28$, $p = .601$ $\eta^2p = .007$, and the Time $\times$ Group $\times$ Grit interaction, $F(2\ 39) = 0.05$, $p = .949$ $\eta^2p = .003$, were not significant.

Table 9

Bonferroni Post Hoc Multiple Comparisons for Behavioral Engagement Across Groups

(I) Group	(J) Group	Mean Difference (I – J)	SE	p	95% CI [LL, UL]
Collaborative	Individual	0.65*	0.07	< .001	[0.48, 0.83]
	Control	1.88*	0.07	< .001	[1.71, 2.06]
Individual	Control	1.23*	0.07	< .001	[1.05, 1.41]

Bonferroni post hoc test results in Table 9 confirmed that the learners in the collaborative condition had the highest behavioral engagement ($MD = 0.65$ vs. individual; $MD = 1.88$ vs. control; both $p < .001$). The individual mind mapping condition also produced significantly higher behavioral engagement than the control group ($MD = 1.23$, $p < .001$). Pairwise comparisons across grit profiles indicated that collaborative activities were associated with high participation metrics regardless of grit level.

The third research question examined the trajectory of the L2 learners' writing anxiety under the different planning modes and grit divisions. To address this question, a three-way mixed-design ANOVA was conducted on the L2 learners' writing anxiety scores. Descriptive values for writing anxiety are reported in Table 10, and inferential statistics including within-subjects effects of the three-way mixed-design ANOVA and post hoc test comparisons are reported in Tables 11 and Table 12, respectively.

Table 10

Descriptive Statistics for Writing Anxiety by Group, Grit Level, and Time

Group	Grit Level	n	Pretest M (SD)	Posttest M (SD)	Total M (SD)
Collaborative	High Grit	8	54.25 (9.98)	40.00 (8.93)	47.13 (9.46)
	Low Grit	7	54.00 (9.45)	41.43 (10.36)	47.72 (9.91)
	Total	15	54.13 (9.39)	40.67 (9.29)	47.40 (9.34)
Individual	High Grit	6	59.00 (8.76)	51.17 (10.32)	55.09 (9.54)
	Low Grit	9	60.33 (9.38)	51.78 (11.41)	56.06 (10.40)
	Total	15	59.80 (8.84)	51.53 (10.61)	55.67 (9.73)
Control	High Grit	8	55.25 (8.65)	54.38 (9.38)	54.82 (9.02)

Group	Grit Level	<i>n</i>	Pretest <i>M (SD)</i>	Posttest <i>M (SD)</i>	Total <i>M (SD)</i>
	Low Grit	7	54.14 (11.13)	51.43 (10.97)	52.79 (11.05)
	<i>Total</i>	15	54.73 (9.53)	53.00 (9.89)	53.87 (9.71)
Total Sample	High Grit	22	55.91 (8.97)	48.27 (11.13)	52.09 (10.05)
	Low Grit	23	56.52 (10.00)	48.52 (11.51)	52.52 (10.76)
	<i>Total</i>	45	56.22 (9.40)	48.40 (11.20)	52.31 (10.30)

Table 11

Repeated-Measures ANOVA Within-Subjects Effects for Writing Anxiety

Source	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>	η^2_p
Time	1346.17	1	1346.17	436.46	< .001	.918
Time $\times$ Group	505.45	2	252.73	81.94	< .001	.808
Time $\times$ Grit	0.48	1	0.48	0.16	.696	.004
Time $\times$ Group $\times$ Grit	12.05	2	6.03	1.95	.155	.091
Error (Time)	120.29	39	3.08			

As detailed in Table 11, the intervention prompted a marked decline in writing anxiety from pretest to posttest, $F(1, 39) = 436.46, p < .001, \eta^2_p = .918$. Notably, this improvement was not uniform; it was significantly moderated by the type of instruction provided, $F(2, 39) = 81.94, p < .001, \eta^2_p = .808$. In contrast, participants' grit levels did not significantly influence these trajectories, neither as a standalone interaction with time, ($F(1, 39) = 0.16, p = .696, \eta^2_p = .004$), nor in combination with the instructional groups ($F(2, 39) = 1.95, p = .155, \eta^2_p = .091$).

Table 12

Pairwise Comparisons for Posttest Writing Anxiety Across Groups and Grit Profiles

Grit Level	(I) Group	(J) Group	Mean Difference (I – J)	<i>SE</i>	<i>p</i>	95% CI [LL, UL]
High Grit	Collaborative	Individual	-11.17	5.55	.051	[-22.39, 0.05]
	Collaborative	Control	-14.38*	5.14	.008	[-24.76, -3.99]
	Individual	Control	-3.21	5.55	.566	[-14.43, 8.01]
Low Grit	Collaborative	Individual	-10.35	5.18	.053	[-20.82, 0.12]
	Collaborative	Control	-10.00	5.49	.076	[-21.10, 1.10]
	Individual	Control	0.35	5.18	.947	[-10.12, 10.82]

Note: *The mean difference is significant at the adjusted alpha level

Posttest-specific pairwise comparisons (see Table 12) clarified the interaction effect. Among high-grit learners, collaborative planning yielded significantly lower posttest anxiety than the control condition ($MD = -14.38$, $p = .008$), while the difference between collaborative and individual planning was not statistically significant ($MD = -11.17$, $p = .051$). Among low-grit learners, differences between the collaborative and individual groups ($p = .053$) and between the collaborative and control groups ($p = .076$) were not statistically significant. The individual and control groups did not differ significantly ($p = .947$).

Discussion

The first research question aimed to investigate the effect of different types of computer-assisted pre-writing planning (i.e., collaborative mind mapping, individual mind mapping, and no mapping) on high- and low-grit Iranian L2 learners' degree of cognitive engagement in online writing classes. The findings indicated that computer-assisted pre-writing planning, particularly collaborative mind mapping, enhanced aspects of the L2 learners' cognitive engagement, as reflected in higher gains in writing complexity and fluency. Collaborative mind mapping allowed the participants to see their peers' ideas and organize thoughts more logically before drafting. The cooperative visual mind mapping exercise served as a scaffold to help them extend their ideas, retrieve vocabulary, and reorganize arguments, thereby producing more complex texts. This process resonates with Swain's (2000) concept of collaborative dialogue, wherein peer interaction facilitates co-construction of knowledge and cognitive processing. Collaborative mind mapping encouraged shared ideation, negotiation of meaning, and elaboration, which are known to foster syntactically more complex written output (Storch, 2005; Wigglesworth & Storch, 2009).

However, a crucial qualification must be made regarding the cognitive engagement results. While complexity and fluency improved, accuracy gains were non-significant across conditions. Conflating multidimensional cognitive engagement exclusively with linguistic performance requires caution. The trade-off between complexity and accuracy observed here aligns with Skehan's (2009) limited attentional capacity model; the L2 learners directed their pooled cognitive resources toward conceptual elaboration and syntactic complexity during collaborative visual planning, which left fewer attentional resources for online linguistic monitoring and formal error correction during drafting. This finding contrasts with studies (e.g., Storch, 2005) reporting concurrent gains in accuracy through collaborative writing, suggesting that computer-assisted pre-writing mind mapping primarily primes semantic and macro-structural processing rather than micro-linguistic precision.

Regarding learner disposition, grit exerted a significant main effect only on fluency, indicating that the high-grit L2 learners demonstrated greater persistence in sustaining physical writing effort and producing longer texts. That is, the L2 learners with higher levels of perseverance sustained effort to write and produce longer texts. Nevertheless, grit did not moderate gains in complexity or accuracy, suggesting that collaborative planning scaffolds cognitive engagement similarly for both high- and low-grit L2 learners.

The second research question investigated the effect of computer-assisted pre-writing planning on high- and low-grit Iranian L2 learners' behavioral engagement in online L2 writing classes. The findings revealed that both collaborative and individual mind mapping significantly increased the L2 learners' behavioral engagement compared to the control group. Mind mapping provided the L2 learners with an explicit task framework, which elevated visible participation, such as contributing ideas and maintaining on-task behavior during online sessions. The collaborative mind mapping group achieved the largest gains because shared brainstorming fostered mutual accountability, encouraging L2 learners to participate more consistently. These findings align with Mohammadi et al. (2024), who observed that pre-writing peer collaboration substantially elevates behavioral involvement.

Grit level did not significantly moderate behavioral engagement. This absence of moderation warrants critical reflection: it demonstrates that pedagogical task architecture in online environments can supersede individual dispositional differences. Because the visual collaborative mind mapping interface provided structured step-by-step external guidance, it sustained the active participation of even the low-grit L2 learners who might otherwise disengage in unstructured online settings. This outcome corroborates Dörnyei's (2019) argument that task design and interactive group dynamics frequently outweigh static learner traits in shaping real-time engagement. Nonetheless, these behavioral findings must be interpreted with caution; engagement was assessed within a single instructional unit using a specific genre, and the division of learners into dichotomous grit categories (high vs. low) may have obscured subtle non-linear effects of perseverance.

The third research question focused on the effects of computer-assisted mind mapping on high- and low-grit Iranian L2 students' writing anxiety. Results demonstrated that computer-assisted pre-writing planning, especially collaborative mind mapping, significantly alleviated the L2 learners' writing anxiety. The individual mind mapping group experienced moderate reductions, whereas the control group exhibited minimal change. This pattern can be attributed to the cognitive and affective functions of pre-task planning. L2 writing often induces anxiety because L2 learners must simultaneously manage ideation, organization, linguistic encoding, and monitoring under working memory constraints. The visual spatialization of concepts and the distribution of the planning burden across peers relieved this cognitive bottleneck. This structured preparation enhanced the L2 learners' perceived task control and self-efficacy.

These findings corroborate Cheng (2002), who demonstrated that pre-writing planning alleviates anxiety through structured task expectations. Moreover, collaborative mind mapping created a supportive peer environment wherein shared responsibility cushioned fear of individual negative evaluation (Horwitz, 2001; Storch, 2005). Contrary to the hypothesis that higher grit would inherently buffer L2 learners against affective distress, grit did not interact with the treatment condition in anxiety reduction in the current study. Structured peer planning acted as an affective scaffold across personality variations.

In sum, these findings demonstrate that computer-assisted collaborative mind mapping serves as an effective instructional intervention to enhance specific facets of cognitive and

behavioral engagement while mitigating writing anxiety in online L2 classrooms. Although dispositional grit fosters text fluency through sustained effort, it does not moderate cognitive complexity or anxiety attenuation very much. From a methodological perspective, while the results are robust, validity threats—such as the reliance on a single prompt topic for posttesting, potential novelty effects of the digital mind mapping tool, and the omission of real-time affective engagement metrics—should be taken into account when interpreting these results and arguing for the outcomes. Also, rather than treating mind mapping as an undifferentiated pre-writing activity, it may be helpful to pair visual mind mapping tools with focused postplanning linguistic editing prompts to bridge the gap between conceptual complexity and grammatical accuracy in online L2 writing instruction.

Conclusion

This study investigated the effects of collaborative and individual computer-assisted mind mapping on cognitive engagement, behavioral engagement, and writing anxiety in online L2 writing courses, accounting for the L2 learners' grit levels. The findings indicate that collaboration remarkably facilitated greater gains in cognitive engagement—specifically regarding complexity and fluency—and behavioral engagement, alongside the most substantial reduction in writing anxiety. While individual mind mapping prompted positive outcomes, its magnitude was less pronounced than that of the collaborative condition. The effect of grit on these outcomes was varied and seemingly limited, with the exception of its effect on fluency. Overall, these outcomes position collaboration as a productive pedagogical approach for online L2 writing classrooms, irrespective of individual grit levels.

The findings offer several key pedagogical implications for L2 writing instruction. First, the findings suggest positive correlation between mind-mapping practices and behavioral and cognitive engagement. Accordingly, L2 teachers should implement such pre-writing tasks within instructional writing modules to enhance engagement. In this way, ideas can be generated more easily and L2 learners can write better essays. Mind maps are among the process-oriented and communicative techniques that require collaboration and planning (Storch, 2013). This issue implies the use of process-based and communicative approaches, which are essential for effective planning (Storch, 2013; Swain, 2000). Second, the reduction of writing anxiety in collaborative environments is an important aspect to consider in relation to instructional techniques employed by L2 teachers. L2 teachers can design group planning exercises that not only facilitate the writing process but also reduce anxiety, thereby fostering confident L2 writers (Cheng, 2004; Horwitz, 2001). Finally, negligible moderating influence of grit in most cases indicates that structured planning tasks are likely to be effective irrespective of the individual personality traits of L2 learners.

Several limitations of the study should be acknowledged. The first one is related to the sample size and the institutional setting, which was small and limited to a single educational context in Iran. Future research could consider larger samples of L2 learners across diverse institutional settings. Another limitation is that this study concentrated on one genre

(argumentative writing) for the data collection, whereas the above mentioned effects might differ in the case of narrative or other genres. Future studies should investigate whether the computer-assisted mind mapping have differential effects for different genres. Another issue relates to the measures of L2 learner engagement and writing anxiety, which were primarily self-report measures. Further research should incorporate other diverse measures of engagement and writing anxiety.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest: The authors declare that they have no competing interests.

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Appendix: Writing Worksheet

Part A (Idea Generation): Read the prompt. Then produce as many ideas to help you write an essay about the prompt. You have 15 minutes. You should complete this task before writing your essay. Do not start writing your essays until your teacher tells you to begin.

Prompt: Individuals can do nothing to help improve the environment; only governments and large companies can make a difference. Do you agree or disagree?

- 1.
- 2.
- 3.

Wait for your teacher to tell you to continue.

Part B (Argumentative Essay). Read the prompt. You have 40 minutes to write your essay.

Prompt: Individuals can do nothing to help improve the environment; only governments and large companies can make a difference. Do you agree or disagree?

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