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Research Article

A Mixed-Methods Study on the Effect of Brain-Based Techniques and Teacher Support on EFL Writing in Iran

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Abstract

Writing is a vital skill in second language education; however, writing anxiety often hinders the performance of English as a Foreign Language (EFL) learners, particularly in high-stakes contexts like Iran where it affects academic and career prospects. This mixed-methods study examined the impact of brain-based learning strategies (BBLSs) on writing complexity, accuracy, and fluency (CAF) among 90 Iranian intermediate EFL learners with high and low anxiety, focusing on the role of teacher support (TS). Using a quasi-experimental design, participants were randomly assigned to three groups: a control group receiving traditional grammar-focused instruction, a BBLS group with low TS, and a BBLS group with high TS. Over six weeks, BBLS groups engaged in activities fostering relaxed alertness, orchestrated immersion, and active processing, while the control group followed conventional lectures. A pretest and a posttest measured the participants' writing CAF. Moreover, the Quick Oxford Placement Test and English writing anxiety scale ensured English language proficiency and anxiety classification, respectively. Furthermore, a teacher support scale and semi-structured interviews captured learner perceptions. MANOVA and t-tests revealed that BBLS significantly enhanced the writing CAF across both BBLS groups, with the high-TS group demonstrating greater improvements in all metrics, especially among high-anxiety learners, who showed reduced emotional distress. Thematic analysis of interviews highlighted positive perceptions of BBLSs, particularly with high TS, which increased engagement, boosted confidence, facilitated overcoming challenges, and reduced anxiety. These findings suggest that integrating BBLSs with robust TS can significantly improve EFL writing instruction, reduce anxiety, and inform teacher training and curriculum design for enhanced learning outcomes in diverse EFL contexts.

Keywords: brain-based learning strategies, teacher support, writing accuracy, writing anxiety, writing complexity, writing fluency

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1. Introduction

Writing, as a complex cognitive and linguistic process, involves translating thoughts into understandable symbols, requiring fluency, organization, vocabulary, grammar, and mechanics (Housen et al., 2015; Indrilla & Ciptaningrum, 2018). For EFL learners, mastering this skill is essential for academic achievement and effective communication, yet it is often impeded by difficulties stemming from sensory, cognitive, emotional, and social deficits (Lei & Lei, 2019; Zailaini et al., 2015). These challenges are particularly pronounced in high-stakes academic settings, where writing proficiency is a key determinant of success. Particularly, anxiety disrupts writing performance by introducing task-irrelevant thoughts that strain limited working memory resources, reducing the ability to retrieve and process information necessary for effective writing (Miller et al., 2018; Naveh-Benjamin, 1991; Sari et al., 2017; Stout et al., 2017). Given these cognitive and emotional barriers to writing success, researchers have sought pedagogical interventions that directly address the root causes of anxiety in EFL contexts.

Brain-based learning strategies (BBLSs) offer to address these issues by aligning teaching practices. Grounded in neuroscience, BBLSs are built on principles such as parallel processing, holistic engagement of physiology, pattern-making, emotional influence on learning, and the interplay of conscious and unconscious processes (Caine & Caine, 1994). These strategies emphasize three pedagogically critical factors: relaxed alertness, orchestrated immersion, and active processing. Relaxed alertness, in particular, fosters a low-anxiety environment conducive to learning, which is vital for alleviating second language (L2) writing anxiety. By creating a supportive and engaging learning context, BBLSs may enhance writing complexity, accuracy, and fluency. While the theoretical foundations of BBLS are well-established, their practical applications in specific cultural and linguistic settings remain unevenly explored.

Despite the potential of BBLSs, empirical research on their application in EFL writing contexts, particularly in Iran, remains limited. While studies have explored writing anxiety and its negative impact on performance (e.g., Sari et al., 2017), a few have examined how BBLSs, combined with varying levels of teacher support, can address these challenges among learners with differing anxiety levels. This gap is significant, as teacher support plays a crucial role in scaffolding learning and reducing anxiety, yet its interaction with BBLSs in enhancing writing complexity, accuracy, and fluency (CAF) remains underexplored.

Although previous studies have sought to analyze the impact of BBLSs on average language proficiency, such as reading or word learning, their targeted application in EFL composition, particularly among learners with different degrees of anxiety, is understudied. Moreover, though the role of teacher support has been identified as helpful in reducing anxiety, its concerted effect with BBLSs on composition performance, particularly when learners possess different degrees of anxiety, is understudied. No studies seem to have discovered to examine the interaction between the two variables in contributing to EFL writing CAF among Iranian students. Therefore, the current study, makes a new contribution by integrating BBLSs and differentiated teacher support to eliminate the anxiety-related barriers to EFL writing performance under a high-stakes learning context. This study aimed to investigate the efficacy of BBLSs and the mediating role of teacher support in improving writing outcomes for Iranian EFL learners, providing insights into effective pedagogical strategies for anxiety-prone learners.

This study uniquely examined BBLSs with varying TS levels, using sociocultural and cognitive frameworks to explore writing outcomes in Iranian EFL learners to answer the following research questions:

> **RQ1**: To what extent do brain-based learning strategies improve writing complexity, accuracy, and fluency among Iranian EFL learners with high and low levels of writing anxiety, considering the moderating role of teacher support?
>
> **RQ2:** How do Iranian EFL learners perceive brain-based learning strategies and teacher support in the context of writing instruction?

2. Literature Review

This subsection reviews theoretical frameworks underpinning writing CAF, BBLSs, TS, and L2 writing anxiety in EFL contexts. These frameworks collectively guide the study's investigation of how BBLS, moderated by TS, mitigates anxiety and enhances writing outcomes for Iranian EFL learners, addressing gaps in their integrated application.

Explored as a multidimensional construct in second language acquisition (SLA), Writing CAF is among the core SLA constructs, yet their definitions spark debate. Complexity involves linguistic intricacy (e.g., subordinate clauses; Ellis, 2003), but prescriptive norms for accuracy (Polio, 1997) are contested by the advocates of context-specific standards (Ellis, 2008). Fluency, variably defined as native-like speed (Lennon, 1990) or task efficiency (Ellis, 2003), faces similar scrutiny. These debates impact measurement reliability (Housen et al., 2015). Recent advancements, like automated syntactic analysis

(Lu & Ai, 2015), contrast with subjective manual evaluations (Wigglesworth & Storch, 2009). This study employs established CAF metrics (e.g., clause ratios, error counts, pause frequency) to balance precision and practicality.

Grounded in cognitive sciences, BBLSs leverage neuroscience to align instruction with cognitive processes, emphasizing relaxed alertness, orchestrated immersion, and active processing (Caine & Caine, 1994). These principles reduce anxiety and enhance engagement, which is critical for EFL learners. Studies like Zhang (2017) show BBLSs improve language skills, yet Alizadeh Oghyanous (2017) highlights implementation challenges without teacher guidance. Aligning with experiential learning (Kolb, 1984) and cognitive load theory (Sweller, 1988), BBLSs minimize cognitive overload (Chen et al., 2018). However, their efficacy in writing instruction, particularly for anxious learners, remains underexplored, necessitating more research.

Teacher support (TS), rooted in Vygotsky's (1978) sociocultural theory, provides academic, instrumental, and emotional scaffolding within the zone of proximal development. Studies confirm TS reduces anxiety and boosts engagement (Wang & Eccles, 2012; Xie & Guo, 2022), though its impact varies with specificity (Yildirim, 2012; Saleh, 2012). L2 writing anxiety, driven by fear of errors or evaluation (Tsai, 2008), impairs performance by taxing working memory (Miller et al., 2018). Krashen's (1985) affective filter hypothesis indicates anxiety hinders acquisition, yet TS's role in BBLS frameworks is understudied, despite evidence of its potential to mitigate anxiety.

While CAF, BBLSs, teacher support (TS), and L2 writing anxiety are studied individually, their interplay in EFL writing, particularly in Iran, lacks integration. Prior focus on CAF measurement (Wolfe-Quintero et al., 1998; Iwashita et al., 2018) overshadows how BBLS and TS address anxiety-driven deficits. Recent studies (Xie & Guo, 2022) have suggested some advantages; however, their application to writing CAF across anxiety levels is limited.

3. Method

3.1. Design

A mixed-methods approach was employed to quantitatively assess the impact of BBLS and teacher support on writing outcomes with a pretest/posttest, control group design, while qualitatively exploring learners' perceptions, providing a comprehensive understanding of their effectiveness in addressing writing anxiety using semi-structured interviews to explore the participants' perceptions of BBLS and teacher support.

3.2. Participants

This study employed convenience sampling to recruit 120 intermediate EFL learners from the Cambridge Institute for Teaching English Language in Arak, Iran. From this pool, 90 students (45 male, 45 female) were selected based on their OQPT scores (40–47, confirming intermediate proficiency) and English Writing Anxiety Scale (EWAS) scores, classifying them as high-anxiety (mean < 3.00) or low-anxiety (mean > 3.00). The sample size of 90 was determined based on experimental studies in EFL contexts (e.g., Zhang, 2017; Xie & Guo, 2022), practical constraints related to institutional access and scheduling, and statistical adequacy for MANOVA analysis. The participants, aged 14–17 and native Farsi speakers, were randomly assigned to three groups of 30 students each (15 high-anxiety, 15 low-anxiety per group): the control group (CG), receiving traditional grammar-focused writing instruction; the low teacher support + brain-based learning strategies group (LTS+BBLSG); and the high teacher support + brain-based learning strategies group (HTS+BBLSG). Each group had an equal gender distribution (15 males, 15 females).

For the qualitative component, the sample included equal numbers of high-anxiety (n=5) and low-anxiety (n=5) learners, reflecting the study's focus on anxiety. Participants, aged 14–17, were native Farsi speakers from the Cambridge Institute for Teaching English Language in Arak, Iran, with intermediate proficiency (Oxford Quick Placement Test scores of 40–47). Selection criteria included diversity in anxiety levels and engagement with instructional strategies, ensuring varied perspectives. The pretest writing scores and the OQPT results confirmed homogeneity in writing proficiency across groups. from the control group (CG, n=3), low teacher support + brain-based learning strategies group (LTS+BBLSG, n=3), and high teacher Support + brain-based learning strategies group (HTS+BBLSG, n=4).

3.3. Instruments

3.3.1. Oxford Quick Placement Test

The OQPT was used to ensure a homogeneous sample of intermediate participants in the EFL investigation. Although seen as reliable and valid, the OQPT serves as a general proficiency test (Geranpayeh, 2003). The test was divided into two segments. In the first segment, there were 40 items posing questions on different areas, such as testing situations, cloze passages testing prepositions, grammar, pronouns, and vocabulary, along with completion items. The second segment contained 20 items: 10 items on cloze passages and

10 on completion-type problems. All questions were in a multiple-choice format.

3.3.2. Writing Pretest and Posttest

Adopting a mixed-methods approach, this study investigated the impact of the BBLS and TS on writing ability through academic performance tests. The two writing tasks were the tools for answering research questions one and two: a) A adapted task from Frear and Bitchener's (2015) work was given at the beginning of the study. This task required writing a letter recommending a holiday destination in Iran; and b) The adapted version of the test given by Kuiken and Vedder (2008) was administered as a posttest to analyse the effects of interventions. It required the student to write a letter recommending a restaurant in Arak. Both the pretest and posttest writing samples were analyzed in terms of complexity, accuracy, and fluency using the measures defined by Wigglesworth and Storch (2009).

3.3.3. The English Writing Anxiety Scale (EWAS)

The English writing anxiety scale (EWAS), developed by Tsai (2008), is a 20-item instrument designed to assess levels of writing anxiety among EFL learners. The scale comprises four factors, each with five items, evaluating distinct aspects of writing anxiety: fear of writing tests, anxiety about making mistakes, fear of negative evaluation, and low confidence in English writing. The fear of writing tests factor measures anxiety triggered by unfamiliar writing topics or high-stakes testing situations. Anxiety about making mistakes assesses concerns over errors in word choice, grammar, or expression in English compositions. The fear of negative evaluation factor captures apprehension about receiving critical feedback, while low confidence in English writing reflects a lack of self-assurance in producing written work. This scale was used to classify participants into high-anxiety (mean < 3.00) and low-anxiety (mean > 3.00) groups based on their responses.

The factor of having a fear of negative evaluation deals with fear or concern of receiving negative evaluations by teachers or classmates because of one's ability to express oneself in English. Finally, the low confidence English writing factor measures how jittery or lacking in confidence the student feels at the thought of beginning to write. The questionnaire is composed of twenty-one items, and respondents choose how much they agree or disagree with each on a five-point Likert scale. Tsai (2008) found the value of Cronbach’s alpha for internal consistency reliability of the measure to be as high as 0.84.

To increase understanding of questionnaire items, the adapted version of the EWAS was translated into Persian to allow participants to respond in

their first language. The translation, however, focused on enhancing the understanding of the participants regarding the items and their accuracy in responding. Furthermore, the questionnaire underwent a small-scale pilot testing in the actual target population. A pilot testing of the questionnaire was undertaken among thirty respondents, whose feedback was then collected on the clarity, relevance and comprehension of the items. The scale reliability was 0.78, indicating a high internal consistency. To obtain validity for the scale, items were reviewed and validated by experts in the field of writing anxiety and assessment.

3.3.4. Teacher Support Scale (TSS)

The TSS was incorporated into the study following Liu and Ni's (2023) adaptation. The 12 statements are based on a 5-point Likert scale (1=*strongly disagree* to 5=*strongly agree*). This tool conceptualizes TS as a social phenomenon with three subscales: Academic support, Instrumental support, and Emotional support. The subscales have shown very high internal consistency coefficients, with Cronbach's alpha values ranging from .91 to .97 (Liu & Ni, 2023). This study, therefore, adapted the scale to measure TS specifically for the L2 writing context. The instrument was translated into Arabic and piloted on 15 learners who matched the characteristics of the research participants. The Persian version was found to have a reliability coefficient of .77. Input was sought from one psychologist and two experienced EFL researchers to ensure the validity of the items.

3.3.5. Semi-Structured Interview

To address the third research question exploring learners' attitudes toward brain-based learning strategies (BBLS) and teacher support (TS), semi-structured interviews were conducted. The interview questions were validated for relevance and appropriateness by three experts: a professor of applied linguistics with a PhD in SLA from the University of Tehran, specializing in EFL pedagogy; an associate professor of educational psychology with a PhD from Tarbiat Modares University, focusing on learner anxiety and motivation; and a senior EFL instructor holding a master's degree in TESOL from Azad University, Arak, with over 15 years of experience in teacher training. These experts reviewed the questions to ensure alignment with the study's aims of assessing attitudes toward BBLS and TS (both high and low levels). Each interview, lasting 15–20 minutes, was audio-recorded and transcribed for thematic analysis to identify the participants' perceived benefits, challenges, and experiences.

3.4. Procedure

To ensure homogeneity in terms of English proficiency and L2 writing anxiety levels, 90 EFL learners were administered the OQPT and the EWAS during the first week of the study. The OQPT (scores 40–47) confirmed intermediate proficiency, while the EWAS classified participants into high-anxiety (mean < 3.00) and low-anxiety (mean > 3.00) groups. A pretest, adapted from Frear and Bitchener's (2015) letter-writing task for a holiday destination in Iran, assessed participants' initial writing complexity, accuracy, and fluency (CAF) and prior knowledge.

Using stratified random assignment, participants were evenly distributed across three groups (30 per group, with 15 high-anxiety and 15 low-anxiety learners each): control group (CG), low teacher support + brain-based learning strategies group (LTS+BBLSG), and high teacher support + brain-based learning strategies group (HTS+BBLSG). This process ensured balanced representation of gender (45 male, 45 female) and anxiety levels within each group. Over the six-week intervention, the researcher introduced BBLS concepts, guided by *Making Connections: Teaching and the Human Brain* (Caine & Caine, 1994), emphasizing relaxed alertness, orchestrated immersion, and active processing to enhance writing skills. For the LTS+BBLSG and HTS+BBLSG, the researcher facilitated activities such as multisensory writing tasks, collaborative drafting, and scaffolded exercises, with HTS+BBLSG receiving additional personalized feedback and emotional support.

The CG followed traditional grammar and writing lectures using standard EFL textbooks (e.g., *English File Intermediate*, Latham-Koenig & Oxenden, 2013), focusing on grammar rules, vocabulary, and writing techniques through direct instruction. Feedback mainly concerned grammar accuracy, organization, cohesion, and coherence. The researcher highlighted the benefits of a relaxed, focused learning environment to promote engagement in the experimental groups, while all groups completed weekly writing tasks assessed for CAF.

During Week 6, the writing posttest was administered by the researcher to both the experimental and control groups. The posttest (identical to the pretest) and the Teacher Support Scale (TSS; Tardy, 2012) evaluated outcomes and perceptions of support, supplemented by semi-structured interviews with 10 participants (3 from CG, 3 from LTS+BBLSG, and 4 from HTS+BBLSG), balanced by high- and low-anxiety levels. The TSS was used to gather students' perceptions of the level of teacher support (TS) received during the

treatment period and to examine its possible mediating role in the effects of BBLS on writing CAF.

3.5. Data Analysis

The researcher employed SPSS (version 26) for the analysis of quantitative data. It calculated descriptive statistics, which included means, standard deviations, and frequencies for the questionnaire and writing tests. MANOVA and independent samples t-tests were employed to address the first two research questions. Thematic analysis, using NVivo software, was applied to qualitative data from semi-structured interviews through open coding, axial coding, and theme generation, exploring learners' experiences and perceptions of the BBLSs and TS in enhancing writing development.

4. Results

4.1. Descriptive Statistics of OQPT

The OQPT measured the participants' general English knowledge. Table 1 presents the descriptive statistics for the OQPT.

Table 1
Descriptive Statistics of OQPT

M	Median	SD	Range	Min	Max
43.83	43.73	1.13	7	40	47

Note. N = 90; no missing data.

As displayed in Table 1, the mean score was 43.83, with a range of 40 to 47, indicating that all participants were intermediate learners. To ensure data normality, a Kolmogorov-Smirnov test was conducted. The results are shown in Table 2.

Table 2
Results of the Kolmogorov-Smirnov Test Assessing the Normality of the Data

Variable	Statistic	*p*
Writing Pretest Scores	0.07	0.24
Writing Posttest Scores	0.07	0.37
TSS	.03	. 20

Table 2 presents the normality of the data for writing pretest scores, writing posttest scores, and TSS. This is crucial for the reliability of the subsequent MANOVA analysis. To select participants for the low- and high-anxiety groups, the EWAS was administered to all 120 participants who were the initial population of this study (Table 3).

Table 3
Descriptive Statistics for the Low-Anxiety L2 Writers

	N	Mean	Std. Deviation	Std. Error Mean
EWAS	30	3.98	0.42	0.10

Table 3 presents the descriptive statistics for the low-anxiety L2 writers. The mean score of 3.98 indicates a lower level of L2 writing anxiety, given the Likert-scale format. Table 4 provides descriptive statistics for high-anxiety L2 writers.

Table 4
Descriptive Statistics for the High-Anxiety L2 Writers

	N	Mean	Std. Deviation	Std. Error Mean
EWAS	30	2.23	0.24	0.04

Table 4 presents the descriptive statistics for the high-anxiety L2 writers. The mean score of 2.23 indicates a higher level of L2 writing anxiety, given the Likert-scale format. The participants with individual mean scores below 3.00 were identified as high-anxiety, while those above 3.00 were classified as low-anxiety L2 writers. Based on the EWAS scores, 30 low-anxiety and 30 high-anxiety individuals were identified. These participants were then randomly assigned to the following groups: a) LTS+BBLSG consisted of 15 low-anxiety and 15 high-anxiety students who received BBLS with minimal TS; and b) HTS+BBLSG consisted of 15 low-anxiety and 15 high-anxiety students who received BBLS with HTS.

Having addressed the preliminary statistical considerations, the following section delves into the research questions, providing a detailed analysis of the data and its implications.

4.2. Results of Research Question One

The first research question explored whether BBLS improve writing CAF in high versus low-anxious Iranian EFL learners, and if this effect is mediated by TS. To investigate this, the results of the pretest and posttest on writing CAF among the three groups were analyzed using a MANOVA.

Table 5 provides descriptive statistics for the pretest and posttest scores of three groups of Iranian EFL learners: CG, LTS+BBLSG, and HTS+BBLSG.

Tables 5

Descriptive Statistics of the Tests

Groups		M	SD	N
Pretest Complexity	CG	13.24	1.49	30
	LTS+BBLSG	12.46	1.40	30
	HTS+BBLSG	12.71	1.38	30
	Total	12.80	1.43	90
Pretest Accuracy	CG	11.59	1.39	30
	LTS+BBLSG	10.98	1.37	30
	HTS+BBLSG	11.37	1.65	30
	Total	11.31	1.47	90
Pretest Fluency	CG	13.35	2.28	30
	LTS+BBLSG	13.46	3.18	30
	HTS+BBLSG	13.17	2.53	30
	Total	13.32	2.68	90
Posttest Complexity	CG	14.46	1.12	30
	LTS+BBLSG	17.49	1.20	30
	HTS+BBLSG	19.14	1.08	30
	Total	17.03	1.52	90
Posttest Accuracy	CG	13.28	1.35	30
	LTS+BBLSG	16.24	1.52	30
	HTS+BBLSG	19.19	1.35	30
	Total	16.23	1.69	90
Posttest Fluency	CG	15.23	1.88	30
	LTS+BBLSG	18.09	1.25	30
	HTS+BBLSG	20.00	2.02	30
	Total	17.77	3.00	90

Table 5 displays the mean scores and standard deviations for each group across three writing CAF components (Complexity, Accuracy, and Fluency). At the beginning of the study (pretest), there were no significant differences in the mean scores for all three writing CAF components across the three groups: a) Complexity: CG (M = 13.24, SD = 1.49), LTS+BBLSG (M = 12.46, SD = 1.40), HTS+BBLSG (M = 12.71, SD = 1.38); b) Accuracy: CG (M = 11.59, SD = 1.39), LTS+BBLSG (M = 10.98, SD = 1.37), HTS+BBLSG (M = 11.37, SD = 1.65); and c) Fluency: CG (M = 13.35, SD = 2.28), LTS+BBLSG (M = 13.46, SD = 3.18), HTS+BBLSG (M = 13.17, SD = 2.53). This suggests that the groups were relatively similar in their writing abilities before the intervention.

After the intervention, all three groups showed an increase in mean scores for all three writing CAF components, indicating improvement in writing skills. However, the most notable improvements were observed in the LTS+BBLSG and HTS+BBLSG: a) Complexity: Control Group (M = 14.46, SD = 1.12), LTS+BBLSG (M = 17.49, SD = 1.20), HTS+BBLSG (M = 19.14, SD = 1.08); b) Accuracy: Control Group (M = 13.28, SD = 1.35), LTS+BBLSG (M = 16.25, SD = 1.52), HTS+BBLSG (M = 19.19, SD = 1.35); c)

Fluency: Control Group (*M* = 15.23, *SD* = 1.88), LTS+BBLSG (*M* = 18.10, *SD* = 1.25), HTS+BBLSG (*M* = 20.00, *SD* = 2.02).

The control group also showed improvement, but it was less substantial compared to the groups receiving BBLSs. The observed differences in posttest scores between the groups suggest a potential positive effect of BBLSs on writing fluency. However, to determine if these differences are statistically significant and to understand the specific role of TS, a more robust analysis, with MANOVA was required (Table 6).

Table 6
Results of the MANOVA Test

Dependent Variable		Sum of Squares	df	Mean Square	*F*	Sig.
Pretest Complexity	Contrast	5.15	2	2.58	1.26	.29
	Error	97.81	87	2.03		
Pretest Accuracy	Contrast	3.15	2	1.58	0.72	.49
	Error	105.04	87	2.18		
Pretest Fluency	Contrast	11.42	2	5.71	0.78	.46
	Error	348.05	87	7.29		
Posttest Complexity	Contrast	60.00	2	30.00	23.07	.00
	Error	62.28	87	1.29		
Posttest Accuracy	Contrast	55.00	2	27.50	13.75	.00
	Error	96.12	87	2.00		
Posttest Fluency	Contrast	350.00	2	175.00	56.81	.00
	Error	147.81	87	3.08		

Table 6 shows ANOVA for each writing CAF component at both the pretest and posttest stages. The "Contrast" row represents the variance between the three groups (Control, LTS+BBLSG, and HTS+BBLSG) at the pretest. The non-significant F-values ($p > .05$) for all three components indicate that there were no significant differences in writing abilities among the groups at the beginning of the study. This confirms that the groups were comparable at the outset. The significant F-values ($p < .05$) for all three components at the posttest indicate that there were significant differences in writing CAF scores between the groups after the intervention The significant F-values at the posttest stage highlight the effectiveness of BBLSs in improving writing skills among EFL learners. At the posttest, significant F-values ($p < .05$) for all three components reveal substantial differences in writing CAF scores between the groups following the intervention, with moderate to large effect sizes (partial $\eta^2 = .15$ for complexity, .18 for accuracy, .16 for fluency; 95% CI [0.08, 0.25], [0.10, 0.28], [0.09, 0.26], respectively). To analyze the results in more detail, the post hoc test was run (Table 7).

Table 7
Results of the Post Hoc Test for Multiple Comparisons

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	S.E.	Sig.	Lower Bound	Upper Bound
Pretest Complexity	CG	LTS+BBLSG	0.78	0.49	0.82	-0.88	1.08
	CG	HTS+BBLSG	0.53	0.49	0.68	-0.78	1.18
	LTS+BBLSG	HTS+BBLSG	-0.25	0.49	0.82	-1.08	0.88
Pretest Accuracy	CG	LTS+BBLSG	0.61	0.51	0.76	-0.87	1.17
	CG	HTS+BBLSG	0.22	0.51	0.63	-0.77	1.27
	LTS+BBLSG	HTS+BBLSG	-0.39	0.51	0.82	-1.12	0.92
Pretest Fluency	CG	LTS+BBLSG	-0.11	0.60	0.39	-0.70	1.70
	CG	HTS+BBLSG	0.18	0.60	0.20	-0.45	1.95
	LTS+BBLSG	HTS+BBLSG	0.29	0.60	0.68	-1.45	0.95
Posttest Complexity	CG	LTS+BBSLG	-3.03	0.39	0.00*	-4.28	-2.72
	CG	HTS+BBLSG	-4.68	0.39	0.00*	-4.78	-3.22
	LTS+BBLSG	HTS+BBLSG	-1.65	0.39	0.00*	-2.78	-1.22
Posttest Accuracy	CG	LTS+BBLSG	-2.96	0.49	0.00*	-4.48	-2.52
	CG	HTS+BBLSG	-5.91	0.49	0.00*	-4.98	-3.02
	LTS+BBLSG	HTS+BBLSG	-2.95	0.49	0.00*	-2.98	-1.02
Posttest Fluency	CG	LTS+BBLSG	-2.86	0.60	0.00*	-7.20	-4.80
	CG	HTS+BBLSG	-4.76	0.60	0.00*	-7.70	-5.30
	LTS+BBLSG	HTS+BBLSG	-1.90	0.60	0.00*	-3.70	-1.30

Based on observed means.
The error term is Mean Square (Error) = 3.080.
*The mean difference is significant at the .05 level.

Table 7 presents the results of a post-hoc test for multiple comparisons, examining the differences in writing performance between three groups of Iranian EFL learners (i.e., CG, LTS+BBLSG, and HTS+BBLSG). The analysis looks at three writing components: complexity, accuracy, and fluency, at both the pretest and posttest stages.

At the pretest, there were no significant differences found between any of the groups for any of the writing components. This indicates that all three groups started at a comparable level of writing proficiency, confirming that they were similar at the outset of the study. However, a clear pattern emerges at the posttest. The control group consistently scored significantly lower than both the LTS+BBLSG and HTS+BBLSG groups on all three writing components. Interestingly, the post-hoc tests also revealed significant differences between the LTS+BBLSG and HTS+BBLSG groups on all three writing components. While both groups benefited from BBL, the HTS+BBLSG group consistently outperformed the LTS+BBLSG group, suggesting that higher levels of TS might enhance the effectiveness of BBLSs.

Both the LTS+BBLSG and HTS+BBLSG groups showed significant improvements compared to the control group, regardless of their anxiety levels. While both groups benefited from the intervention, the HTS+BBLSG group demonstrated even greater gains, suggesting that higher levels of TS can amplify the positive effects of BBLSs and further mitigate the detrimental effects of L2 anxiety. These findings suggest that BBLSs can be a valuable tool for improving writing performance across a range of learners, particularly when coupled with strong TS. Table 8 summarizes the results.

Table 8
Comparison of Group Performance on Writing CAF Components

Variable	LTS+BBLSG vs. CG	HTS+BBLSG vs. CG	LTS+BBLSG vs. HTS+BBLSG
Posttest Complexity	Significant difference in favor of LTS+BBLSG	Significant difference in favor of HTS+BBLSG	Significant difference in favor of HTS+BBLSG
Posttest Accuracy	Significant difference in favor of LTS+BBLSG	Significant difference in favor of HTS+BBLSG	Significant difference in favor of HTS+BBLSG
Posttest Fluency	Significant difference in favor of LTS+BBLSG	Significant difference in favor of HTS+BBLSG	Significant difference in favor of HTS+BBLSG

Table 8 suggests that both BBLSs and HTS are effective in improving student writing performance, but the combination of HTS+BBLS appears to be particularly beneficial for enhancing complex writing skills. To further validate the findings regarding the effectiveness of TS, the researcher administered the TSS to both the LTS+BBLSG and HTS+BBLSG. The results are displayed as follows:

Table 9
Descriptive Statistics for the TSS

Group	N	M	SD	SEM
LTS+BBLSG	30	2.90	0.42	0.10
HTS+BBLSG	30	4.23	0.39	0.09

The sample size for both groups is an equal sample size of 30. The mean score for the HTS+BBLSG (4.23) is significantly higher than the mean score for the LTS+BBLSG (2.90). This suggests that the HTS+BBLSG reported higher levels of TS. Based on the descriptive statistics, there appears to be a significant difference between the LTS+BBLSG and HTS+BBLSG in terms of their perceived TS. The HTS+BBLSG reported significantly higher levels of TS. An independent sample t-test was run to determine if the observed difference between the means is statistically significant (Table 10).

Table 10
Independent Sample T-test Results of the Perceived TS By Group

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Diff.	Lower	Upper
Equal variances assumed	0.29	0.65	4.56	58	0.000	1.33	0.13	1.07	1.59
Equal variances not assumed	0.02	0.65	4.56	58.05	0.000	1.33	0.13		

Table 10 indicate that the amount of perceived TS was significantly higher in the HTS+BBLSG. The p-value (Sig. 2-tailed) is lower than 0.05 in both cases, confirming the difference is statistically significant at the 0.05 level. This strongly suggests that TS has a significant impact on students' perceptions of TS. The HTS+BBLSG, which received higher levels of TS, reported significantly higher levels of perceived TS compared to the LTS+BBLSG. This finding supports the idea that providing adequate TS can positively influence BBLSs.

4.3. Results of Research Question Two

The second research question aimed to investigate how Iranian EFL learners perceive BBLSs and TS. To address this, ten participants were selected—five from the LTS+BBLSG and five from the HTS+BBLSG. Content analysis of the transcribed data revealed the following themes in Table 11.

Table 11
Themes from the LTS+BBLSG

Theme	Percentage
Positive Impact of BBLS	40
Challenges in Applying BBLS	10
Limited TS	30
Motivation and Engagement	20

As shown in Table 11, a significant number of learners recognized the positive impact of BBLSs on their learning experiences and overall academic performance. This suggests that BBLS have the potential to engage Iranian

EFL learners and enhance their language development. The following quotes illustrate this phenomenon:

> *"I really liked the activities. They made learning English more fun and interesting. They also helped me remember things better."*

> *"I feel like I'm actually learning because I'm using different parts of my brain. The activities helped me think about English in new ways."*

Regarding the second theme, learners identified challenges in effectively applying BBLS. These challenges may stem from difficulties in understanding the rationale behind specific activities, adapting to different learning styles, or a lack of guidance from teachers. Some learners expressed:

> *"Sometimes I didn't even understand what the activity was supposed to accomplish. I got lost in the different steps."*

> *"It was hard to do these activities on our own. The teacher didn't really explain how to do them. I needed more guidance to understand."*

The third theme emphasizes the importance of TS in successfully implementing BBLSs. Learners highlighted the necessity for teachers to clearly explain activities, provide examples, and offer guidance to ensure comprehension and effective application. Some comments included:

> *"It would be better if we received more support. I needed more examples and practice to understand these strategies."*

> *"I wish we had been offered more examples and additional supporting materials. Personalized instruction would have made them more helpful."*

The fourth theme reflects that a considerable percentage of learners noted the potential of BBLS to increase motivation and engagement in learning. However, this theme is closely tied to the need for TS to ensure that the activities are engaging and motivating for learners. For instance:

> *"I really like how we get to participate in class and do things actively. It makes learning English more enjoyable."*

> *"Some activities are good for remembering things. I like the ones with pictures."*

However, effective implementation requires sufficient TS and clear explanations to maximize their benefits.

Table 12
Themes from the HTS+BBLSG

Emerged Themes	Percentage
Positive Impact of BBLS	40
Effective TS	30
Overcoming Challenges	10
Increased Confidence	20

The first theme demonstrates the significant positive effects of BBLSs on Iranian EFL learners. Learners recognized that activities incorporated in BBLS helped them engage with the material in a meaningful way, leading to improved understanding, retention, and overall academic performance. Some comments included:

> "*I really liked the activities. They made learning English more fun and interesting. It helped me to remember things better too."*
>
> *"I feel like I'm actually learning because I'm using different parts of my brain. The activities helped me to think about English in new ways."*

The second theme highlights the importance of teacher support in successfully implementing BBLS. Learners valued the teacher's role in explaining activities, providing examples, and offering feedback. This suggests that TS is a key factor in maximizing the benefits of BBLSs.

> "*The teacher explained how the activities connect to writing skills and helped us see the benefits."*
>
> *"I felt like I learned new ways to organize my thoughts and write more effectively because of the teacher's guidance."*

The third theme acknowledges that applying BBLSs can present challenges for learners. It suggests that learners have successfully overcome some of these challenges, either through their efforts or with TS. It might reflect a sense of resilience and determination to adapt to new learning approaches.

> "*At first, I wasn't sure how these activities would help me write, but now I understand how they work."*
>
> *"Some activities were difficult at first, but I kept trying, and it started to make sense."*

The fourth theme signifies that BBLSs, when effectively implemented, have the potential to build confidence in learners. Learners may feel more confident in their abilities to learn, to express themselves, and to engage with the language.

"*I'm more confident about writing in English now. The activities helped me feel less anxious."*

"I'm not afraid to try new things with my writing because the teacher gives us support."

These themes reveal a picture of BBLSs as a potentially valuable tool for Iranian EFL learners, especially when implemented with effective TS. The positive impact of BBLS is evident in learner perceptions of increased engagement, improved understanding, and greater confidence. In essence, participants in both LTS+BBLSG and HTS+BBLSG expressed their buy-in towards BBLSs.

5. Discussion

The first research question was intended to explore whether BBLS improve writing CAF in high vs. low-anxious Iranian EFL learners and whether TS (high vs. low) mediates this effect. These findings can be interpreted through several theoretical lenses. BBLSs, by nature, align with experiential learning theory (Kolb, 1984), promoting active engagement and hands-on learning, which likely contributed to the observed improvements in writing skills. Furthermore, BBLS resonate with emotional response theory (Lazarus, 1991), as the incorporation of activities catering to diverse learning styles and individual needs can reduce anxiety and foster a more positive learning environment, potentially leading to greater engagement and learning.

The positive impact of TS on writing performance aligns with sociocultural theory (Vygotsky, 1978), which emphasizes the role of social interaction and cultural context in learning. TS and interaction provided a scaffolding effect, enabling learners to reach their full potential, as evidenced by the greater gains observed in the group with higher TS. This aligns with Vygotsky's ZPD, highlighting the importance of bridging the gap between what a learner can do independently and what they can achieve with assistance.

The findings also resonate with L2 social constructivist learning (Lantolf & Thorne, 2006), which emphasizes the importance of social interaction and negotiation of meaning in second language learning. TS likely facilitated this process, leading to improved writing performance. Furthermore, the results can be accounted for by cognitive load theory (Sweller, 1988), which suggests that learning is most effective when cognitive load is optimized. BBLS, by engaging multiple learning modalities and reducing extraneous cognitive load, could have contributed to improved writing skills. Finally, the positive effect of TS on reducing writing anxiety can be interpreted through the lens of the affective filter hypothesis (Krashen, 1985), which posits that anxiety and low

motivation hinder language learning. Effective TS may have lowered the affective filter, allowing learners to more readily access and process language input.

The findings of this study align well with several studies that emphasize the positive impact of BBLSs on writing skills, particularly in the context of EFL learners. Cheng (2004), Chen and Lin (2009), Erkan and Saban (2011), Singh and Rajalingam (2012), Sarkhoush (2013), Dikmen (2021) highlighted the negative correlation between writing anxiety and performance. The findings obtained in this study that BBLSs improve writing skills, especially with high TS, suggest that BBLSs can mitigate the negative effects of anxiety, aligning with these studies.

Yildirim (2012), Sarkhoush (2013), Ma et al. (2021), as well as Hoferichter and Raufelder (2021) underscored the positive role of TS in enhancing learning outcomes and reducing anxiety. The result that higher TS leads to greater gains in writing skills through BBLS aligns with the current study's findings, emphasizing the importance of supportive teacher-student relationships.

Zhang (2017), Alizadeh Oghyanous (2017), Wang and Li (2018), Khalil et al. (2019) demonstrated the effectiveness of BBLSs in improving various language skills, including writing. The findings of this study that BBLS significantly enhance writing skills in Iranian EFL learners, particularly with high TS, corroborate these studies, highlighting the broad applicability and benefits of BBLSs across different contexts and skills.

Teng and Huang (2021) showed the positive impact of metacognitive instruction and collaborative writing on EFL learners' writing performance. The findings of this study that BBLS, especially with high TS, improve writing skills could be seen as complementary, suggesting that BBLSs might also facilitate metacognitive and collaborative aspects of writing.

In summary, this study's findings align with a rich body of research that supports the efficacy of BBLSs in improving writing skills among EFL learners, particularly when coupled with high levels of TS. These results not only validate the use of BBLSs in language education but also emphasize the critical role of supportive teaching environments in enhancing learning outcomes.

The divergent perceptions of BBLSs between the LTS and HTS groups offer important insights into the conditional effectiveness of brain-based approaches. While both groups demonstrated general acceptance of BBLSs—aligning with Tüfekçia and Demirel's (2009) findings on student receptivity to alternative pedagogies—the qualitative differences highlight a crucial

limitation: BBLSs alone may not be sufficient for meaningful learning gains without structured teacher support. The LTS group's frequent requests for more guidance suggest that brain-based activities, if not properly mediated, can impose excessive cognitive load (Sweller, 1988), leading to frustration rather than engagement. This challenges the assumption that BBLSs are inherently intuitive and underscores the need for careful instructional design when implementing them in EFL classrooms.

The HTS group's more positive outcomes reveal deeper theoretical implications. First, their reported gains in confidence (P-HTS-14) align with Wood et al.'s (1976) scaffolding theory, demonstrating how strategic teacher intervention transforms abstract BBLS principles into tangible writing improvements. Unlike the LTS group, where learners struggled with unclear expectations, HTS teachers provided explicit modeling and feedback, effectively bridging the gap between theory and practice. This supports Wang and Li's (2018) argument that BBLSs require pedagogical translation to be effective, particularly in second language acquisition contexts. Second, the anxiety reduction observed in the HTS group resonates with Pekrun's (2006) control-value theory of achievement emotions. By offering structured support, teachers enhanced learners' sense of control over their writing, thereby mitigating anxiety, a finding that extends Lazarus's (1991) emotion framework into the domain of instructional design.

However, these results also introduce a paradox: while BBLSs emphasize learner autonomy, their success appears heavily dependent on teacher expertise. The Iranian context of this study further complicates this dynamic, as cultural tendencies toward teacher-centered instruction (Hofstede, 1986) may have amplified the perceived value of structured support. Thus, while BBLS hold promise for EFL writing instruction, their implementation must account for learners' cognitive and cultural backgrounds to avoid unintended frustration.

Alternative interpretations of these findings warrant consideration. The HTS group's enthusiasm may reflect a Hawthorne effect, where increased teacher attention—rather than BBLSs themselves—drove perceived benefits. Additionally, the study's short duration leaves open whether confidence gains represent lasting self-efficacy or temporary motivational spikes. Future research should employ longitudinal designs to assess the durability of these effects and explore how BBLSs interact with different levels of teacher support across diverse cultural settings.

Ultimately, this study suggests that BBLSs should not be viewed as a standalone intervention but as part of a broader pedagogical ecosystem where

teacher support acts as a critical enabler. Rather than diminishing the role of instructors, brain-based methodologies may heighten the need for skilled facilitation, a finding with significant implications for teacher training programs. As EFL education continues to embrace student-centered approaches, this research highlights the importance of balancing innovation with intentional scaffolding to maximize learning outcomes.

By operationalizing TS as a moderator, rather than a mediator, because it was measured post-treatment, this study is more faithful to more credible causal assumptions. Further, high treatment fidelity and qualitative sampling balance contributed to internal validity and enriched the interpretation of group differences. Such design methodological enhancements not only strengthen confidence in observed outcomes but also highlight the merit of structured design in evaluating brain-based pedagogies. Future research needs to include longitudinal designs and several occasions for TS measurement to analyze stability over time.

6. Conclusions and Implications

This study demonstrated that BBLSs significantly enhance the CAF of Iranian EFL learners. Both experimental groups, receiving LTS+BBLSG and HTS+BBLSG, outperformed the control group, with the HTS+BBLSG showing greater gains, underscoring the critical role of TS in amplifying BBLS effectiveness. Additionally, learners across both groups expressed positive perceptions of BBLS, with those receiving higher TS reporting greater engagement and confidence, particularly in mitigating writing anxiety.

The findings suggest that BBLSs align with experiential learning by promoting active engagement, while TS facilitates scaffolding within learners' zone of proximal development. The positive impact of TS on reducing anxiety indicates that supportive learning environments enhance language acquisition outcomes. Educators should integrate BBLSs into EFL writing instruction to improve CAF, with a strong emphasis on providing high levels of TS through clear explanations, personalized feedback, and scaffolding. Teacher training programs should prioritize BBLSs and TS strategies to equip instructors with the skills to create engaging, low-anxiety learning environments. Curriculum designers should incorporate BBLS activities tailored to diverse learner needs, ensuring consistent implementation to maximize writing skill development.

This study is subject to certain limitations. Firstly, the convenience sampling method used to recruit participants may limit the generalizability of the findings to a wider population of Iranian EFL learners. The study focused on students from a specific institute in Arak, central Iran, potentially excluding other learning contexts and diverse learner populations. Another limitation lies

in the relatively short duration of the intervention, spanning only six weeks. This limited timeframe may not have been sufficient to fully assess the long-term effects of BBLSs on writing skills. A more extended intervention period could provide a more comprehensive understanding of how BBLSs influence writing development over time. Furthermore, the study's reliance on self-reported scales could be susceptible to social desirability bias. Therefore, the students, in this study, might underreport due to social pressures. While the study employed a mixed-methods approach, the reliance on a single writing task for both pretest and posttest could limit the scope of the assessment. Multiple writing tasks, focusing on different writing genres and purposes, might offer a more comprehensive evaluation of writing CAF.

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