

## Article

# Effects of the Fundamental Concepts of Computational Thinking on Students' Anxiety and Motivation toward K-12 English Writing

Hsi-Hung Peng<sup>1</sup>, Astrid Tiara Murti<sup>2</sup> , Lusia Maryani Silitonga<sup>2,3</sup> and Ting-Ting Wu<sup>2,\*</sup> 

<sup>1</sup> Department of Industrial Education and Technology, National Changhua University of Education, Changhua 500, Taiwan

<sup>2</sup> Graduate School of Technological and Vocational Education, National Yunlin University of Science and Technology, Douliu 640, Taiwan

<sup>3</sup> Master of English Education Department, Universitas PGRI Semarang, Semarang 50232, Indonesia

\* Correspondence: ttwu@yuntech.edu.tw; Tel.: +886-5-5342601 (ext. 3031)

**Abstract:** Computational thinking (CT) skills are now a key part of everyday life and work, and CT has been incorporated into K-12 curricula worldwide. Combining the fundamental concepts of CT with English writing constitutes an innovative and sustainable learning strategy. However, few academic studies have examined the incorporation of CT into English writing. English writing frequently generates excessive stress and anxiety among students, yet motivation can mitigate the negative effect of anxiety. This study investigated the effects of the fundamental concepts of CT on reducing writing anxiety and increasing motivation toward English writing. A quasi-experimental design was applied, and data were collected from experimental and control groups through writing anxiety and motivation questionnaires. The results indicated that the fundamental concepts of CT exerted a more significant influence on the dimensions of writing anxiety and motivation than did a conventional learning method. In conclusion, the fundamental concepts of CT promoted organized and structured English writing, increased students' writing motivation, and reduced their writing anxiety.

**Keywords:** computational thinking; innovative teaching and learning method; writing; anxiety; motivation



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## 1. Introduction

Writing—one of the four core language abilities in addition to listening, speaking, and reading—is essential for academic success, serving as a crucial medium through which students can express their thoughts and opinions [1]. In language learning, writing assists learners with learning, communicating their ideas, and persuading others. As a productive skill, writing requires that students engage in a purposeful, creative, and complex cognitive process [2]. Students must comprehensively understand the English language, including such aspects as vocabulary, grammar, sentence structure, text organization, rational thinking, and arguments [3]. In the last two decades, English writing skills have drawn increasing academic interest, with researchers employing a variety of learning strategies to promote English writing skills among students [4]. To mitigate English as a foreign language (EFL) writing difficulties, teachers can employ sustainable teaching strategies that strengthen students' writing cognition and sustain their learning motivation in order to reduce their fear of English writing.

Computational thinking (CT) has been extensively integrated into the K-12 educational curriculum to establish a foundation for strong student performance and global sustainability in line with the Sustainable Development Goals for quality education [5,6]. Incorporating real-world applications and more hands-on project-based learning activities

into the curriculum, and increasing technology use in the classroom can help K-12 students better understand the material and how it applies to their lives. Computational thinking is a problem-solving strategy applicable across the K-12 curriculum and growing in importance in the 21st century. Integrating technology into the traditional base and elective areas of study can assist students in making crucial cross-curricular relations, thereby enhancing their academic performance and developing essential skills for problem-solving in the wide range of careers in which they will engage in the future [7]. Additionally, researchers have proposed that an innovative and sustainable teaching strategy could be developed by combining the fundamental concepts of CT with English language learning [4,8,9]. The authors of [10] first introduced CT as a fundamental skill alongside reading, writing, and arithmetic. CT begins with problem identification and solution development, which involve decomposition, abstraction, pattern recognition, algorithm, generalization, and evaluation [8,11]. Following the characterization of CT as a fundamental skill proposed by [10], CT has also been proposed as a conceptual model that can foster English writing skills and support the comprehension of text, acquisition of vocabulary, and visualization of grammar rules [9,12]. CT constitutes a novel form of writing instruction that employs the basic principles of computer science. Researchers have asserted that incorporating CT into English teaching could improve students' writing by guiding them through a sequential process of identifying problems, organizing and representing information, and improving sentence structure in order to boost their motivation [4,9,13–15]. Additionally, understudied is the integration of the fundamental concepts of CT in K-12 as a medium for teaching problem-solving [16,17]. CT is an innovative approach that is vital for students in the 21st century to possess, which resolves real-world challenges in an effective and efficient manner, including problem-solving, critical thinking, and creativity [18].

The fear of making mistakes, embarrassing oneself, or not being able to express one's ideas leads to excessive stress and self-consciousness among EFL students, often manifesting as anxiety [19–21]. Anxiety can pervade every aspect of a person's life, including their writing ability, as a naturally occurring phenomenon. Many students perceive English writing to be difficult, and thus, are anxious about being asked to write in English [2,22]. Multiple studies have focused on the connection between writing and anxiety in EFL [3,23,24]. Maintaining interest in learning English might be challenging for students if they are only occasionally exposed to the language in a classroom setting [23]. However, researchers have argued that motivation can counter the negative effect of anxiety [24–26]. Writing anxiety can cause students to feel overwhelmed, frustrated, and discouraged, and thus, can lead to a lack of motivation to write. Additionally, students who experience writing anxiety may be less likely to take risks and be creative in their writing, and thus, may have further reduced motivation. By contrast, students who are motivated to write may be more likely to take risks and be creative, which can assist them in overcoming their writing anxiety. The authors of [27] stated that motivation could increase students' efforts to improve their writing skills. Therefore, teachers must establish a supportive classroom atmosphere where students do not fear making mistakes and may freely express themselves; such an atmosphere can help to reduce students' writing anxiety and increase their motivation to write.

Some studies have investigated the affective factors of language learning and have revealed that anxiety and motivation play a key role in EFL writing performance [23,24]. In addition, researchers have reported that using CT can improve students' motivation to learn [4,14,15]. Writing motivation and anxiety affect the success of foreign language learning; anxiety can have an unfavorable effect that can be countered by motivation. This study explored whether improvements to teaching strategies can influence students' motivation and writing anxiety. CT can reduce English writing anxiety by guiding students to break down tasks into manageable steps so that the entire process is perceived to be less daunting. Additionally, understanding how to use the fundamental concepts of CT can assist students in organizing their thoughts before writing, thereby increasing the efficiency and effectiveness of the overall process. However, few studies have investigated

the combination of CT and language learning [8,12,28,29], and fewer still have applied CT to English writing [4,30]. Thus, this study addressed this research gap by developing an innovative teaching strategy for K-12 English writing derived from the conceptual model of CT. In addition, this study examined the impact of the fundamental concepts of CT as a learning strategy in relation to students' anxiety and motivation in order to address the following research questions:

- a. Does incorporating the fundamental concepts of CT into English writing classes reduce students' anxiety toward English writing more effectively than a conventional teaching method?
- b. Does incorporating the fundamental concepts of CT into English writing classes affect students' motivation toward English writing more heavily than a conventional teaching method?

## 2. Literature Review

### 2.1. Integrating the Fundamental Concepts of CT into an English Writing Course

CT begins with the learner being confronted by problems and subsequently engaging in solution development, which involves decomposition, generalization, abstraction, algorithm, and evaluation. The authors of [31] described CT as a basic skill for student problem-solving, indicating that to formulate a solution to a problem, the student must precisely comprehend the nature of the problem. The fundamental concepts of CT involve decomposition, pattern recognition, algorithm, abstraction, and evaluation [8,12,32]. These concepts include segmenting a complex problem into smaller, more manageable subproblems (decomposition), recognizing the pattern underlying these subproblems (pattern recognition), employing a series of steps to solve these subproblems (algorithm), analyzing how the solution may transfer to similar situations (abstraction), and making sound judgments regarding the various solutions (evaluation) [8,12].

Taiwanese high school students are typically novice English writers because they are seldom required to do English writing [2,20]. Writing is a difficult task. A skilled writer must learn and master lexical knowledge for text composition, whereas inexperienced writers demonstrate poor planning behaviors and have narrow conceptions of what writing involves. Researchers have explored the causes of students' difficulties in mastering English writing [3,33,34]. Students often do not know which words or phrases to use and have difficulty determining whether the words chosen are accurate [35]. Before and during essay writing, students frequently review small sections of their writing material, yet their initial draft typically becomes the final version [34]. In addition, the majority of students struggle with outlining and organizing their ideas before starting the writing process [2]. Furthermore, students who lack experience in developing ideas, structure, organization, and mechanics make frequent grammatical and typographical mistakes. Among the various strategies proposed to improve students' writing skills, the fundamental concepts of CT were introduced to teach writing as a problem-solving process that emphasizes idea organization, advanced writing competence, and student-to-student interaction.

CT is considered an essential ability in the 21st century, and an increasing number of countries are incorporating CT into classroom teaching [5,36]. However, the use of the fundamental concepts of CT to teach disciplines other than programming has seldom been studied [12]. Studies have verified that CT can enhance language abilities by providing a systematic problem-solving method for English writing [4,37,38]. Incorporating the fundamental concepts of CT can assist students in writing methodically and mastering writing mechanics by prompting students to identify various sentence structures through the linguistic analysis of sentences [8]. In addition, this approach can assist in identifying areas where additional guidance may be required, such as grammar and spelling.

In English writing, CT is used to guide students in developing their writing skills by providing them with the skills to analyze writing tasks, explore writing styles, and practice writing in multiple contexts [12,39]. Decomposition is often used in writing to break down complex ideas into more manageable parts, enabling students to effectively synthesize

their thoughts and create coherent writing pieces expressing their opinions. According to [40], brainstorming is a useful technique for decomposing ideas and creating detailed outlines of the key points in sentences. The authors of [41] asserted that brainstorming activities among students could consolidate related background information about a topic. Pattern recognition is a key skill through which students identify patterns in decomposed ideas. After identifying a pattern, students can concentrate on the verbs and predicates in all the sentences involved. According to [39], students learn to recognize grammatical patterns and use them to construct clear and concise sentences. In addition, they learn to recognize sentence structure patterns and use them to create a logical flow of ideas. Abstraction implies generalizing and applying the same problem-solving method to similar situations [42]. In English writing, students can utilize their existing knowledge of nouns, pronouns, adjectives, verbs, adverbs, articles, prepositions, conjunctions, and interjections to write complete sentences. However, although students may spend considerable time decomposing ideas, recognizing patterns, and applying abstraction, they may still need clarification about how to arrange their ideas coherently. Algorithm or algorithmic thinking involves using a sequence of step-by-step instructions to compose phrases; this series of instructions can later be applied to perform similar tasks [42]. Finally, to evaluate the correctness of their written sentences, students are encouraged to analyze and evaluate one another's work. Peer evaluation among students can encourage collaboration and creativity in developing the optimal solution to a problem.

## 2.2. Writing Anxiety and Motivation

Writing apprehension is a distinct type of anxiety experienced during the English writing process that must be addressed by EFL teachers [21,22]. Writing anxiety refers to an inner propensity for anxiousness that interferes with a person's ability to complete required writing tasks that they are cognitively capable of completing [43]. The authors of [21] used the term "writing anxiety" to characterize an inherent fear of the writing process that interferes with an individual's ability to work on a writing task and reduces the expected gain of writing. Writing anxiety has physiological and cognitive effects on writing processes and behaviors [3,23]. The authors of [22] identified cognitive anxiety, somatic anxiety, and avoidance behavior as the three components of writing anxiety. Cognitive anxiety refers to the fear of being negatively evaluated, somatic anxiety can be defined as the physiological manifestation of anxiety, and avoidance behavior generally manifests in students as the avoidance of writing tasks.

Empirical studies of English writing anxiety have revealed the following causes of writing anxiety: (1) Negative feedback from teachers and peers; (2) Inadequate writing skills that prevent the articulation of thoughts in writing; (3) Deficiencies in technical instruction for students' writing; and (4) Time constraints for drafting and revising texts [3,44,45].

Students who experience a high level of writing anxiety typically lack motivation, hold unfavorable attitudes toward writing assignments, generate low-quality content, have negative perceptions about their writing ability, and are relatively likely to avoid situations where writing is required [2,20,24,25,46]. According to [47], highly apprehensive individuals avoid writing because they fear negative evaluation; if they are required to write, they experience strong feelings of anxiety. The most anxiety-provoking factors in writing include but are not limited to selecting a writing topic, generating additional thoughts, working under time constraints, and receiving insufficient valuable feedback. Writing-process-specific steps—such as grammar use, brainstorming, and idea organization—can also cause anxiety [40].

The authors of [45] discovered that modifications to teachers' teaching approaches, such as using process-based teaching methods, might reduce students' writing anxiety. In addition, educational researchers have proposed novel strategies for integrating the fundamental concepts of CT into classroom teaching activities to enhance students' motivation to learn [5]. Motivation reflects the successful implementation of pedagogical strategies in the classroom. According to [48], motivation is a variable that is likely to

change over time. Writing motivation is a construct composed of the dimensions of an individual's self-perception as a writer, belief in the value of writing, and attitude toward writing [33]. The authors of [49] identified three indicators of writing motivation, which are self-efficacy beliefs, mastery goals, and performance goals. Self-efficacy beliefs refer to the beliefs in one's competence, mastery goals emphasize personal growth and development, and performance goals refer to the motivation to do better than everyone else's.

Additionally, motivation is a key factor in determining foreign language anxiety [23,50]. Moreover, the authors of [26] argued that motivation could completely eliminate writing anxiety and that teachers' encouraging assessment of students' writing is the most crucial factor in reducing second language writing anxiety.

In the previous section, the integration of fundamental concepts of CT into the English writing course was outlined. It is important to recognize that the fundamental concepts of CT might have an impact on writing anxiety and motivation. Breaking down a complex problem into smaller subproblems can help alleviate feelings of being overwhelmed, while recognizing patterns and developing algorithms can aid the development of the writing assignments. Therefore, it is crucial for the teacher to be mindful of how these fundamental concepts of CT can affect students' anxiety and motivation levels, and to provide support and guidance to help students navigate these writing assignments.

### 2.3. The Hypotheses Development

Based on the related studies, classroom teaching and learning influence students' writing anxiety and motivation [5,45,46]. The fundamental concept of CT encourages students to solve problems analytically and systematically [8,12,36,51]. It has become an important part of education, and by implementing the fundamental concept of CT in English writing courses, it is expected that the students will feel more prepared and motivated to tackle writing assignments. Therefore, this study seeks to examine the impact of the fundamental concept of CT in relation to students' writing anxiety and motivation. The following hypotheses are proposed:

**Hypothesis 1:** *Incorporating the fundamental concepts of CT into English writing classes will be more effective in reducing students' (a) cognitive anxiety, (b) somatic anxiety, and (c) avoidance behavior than a conventional teaching method.*

**Hypothesis 2:** *Incorporating the fundamental concepts of CT into English writing classes will have a stronger positive effect on students' (a) self-efficacy beliefs, (b) mastery goals, and (c) performance goals than a conventional teaching method.*

## 3. Methodology

### 3.1. Research Design

A quasi-experimental approach was employed in this study to investigate the effects of CT on students' anxiety and motivation. Two instructional strategies served as the independent variables of this study, namely teacher-led content-based instruction and the fundamental concepts of CT in English writing. The factors of writing anxiety and motivation were measured using 5-point Likert-scale questionnaires where the Second Language Writing Anxiety Inventory (SLWAI) developed by [22] and the Writing Task Motivation (WTM) tool developed by [49] were used for data collection. Quantitative data were produced from the pretest and posttest data gathered through the self-assessment questionnaires.

### 3.2. Participants

The participants of this study were 58 first-year high school students enrolled in an English writing course. Demographically, the group was composed of 16 males and 13 females for the experimental group, and 14 males and 15 females for the control group, with an average age of 16. The course was designed to assist K-12 students in developing

their English writing abilities. For the quasi-experimental design, students in one class were designated as the control group, and those in another class were designated as the experimental group. The same assessment and course materials were assigned to both classes, but different instructional strategies were employed for the experimental and control groups. The students in the control group were taught English writing according to standard teacher-centered training, whereas those in the experimental group were taught English writing in accordance with the fundamental concepts of CT. These concepts constitute a novel form of writing instruction. The same teacher with more than ten years of teaching experience taught both classes. Before the experiment, the teacher and a professor who had studied CT discussed the lesson plan for incorporating the fundamental concepts of CT into English writing training.

### 3.3. Experimental Procedure

The experimental procedure was conducted for 9 weeks, with classroom instruction provided in one 50 min session each week. The experimental procedure is illustrated in Figure 1. As mentioned, a control and experimental group design was applied in this study. The first and second weeks of the course for both groups involved prequestionnaire completion and course orientation, during which the teacher introduced the course objectives and content as well as the rationale for cultivating English writing ability. From the third week to the eighth week, one topic was assigned every two weeks for the writing activities of the control and experimental groups. The assignments covered several topics, including recipe instructions, hobbies, and Kaohsiung City. After the students had finished their writing drafts, their writing was evaluated by their peers. The writing practice and the discussion activities in the experimental group can be seen in Figure 2. The postquestionnaires, which were the same as the prequestionnaires, were administered in the ninth week, directly after the experimental treatment.

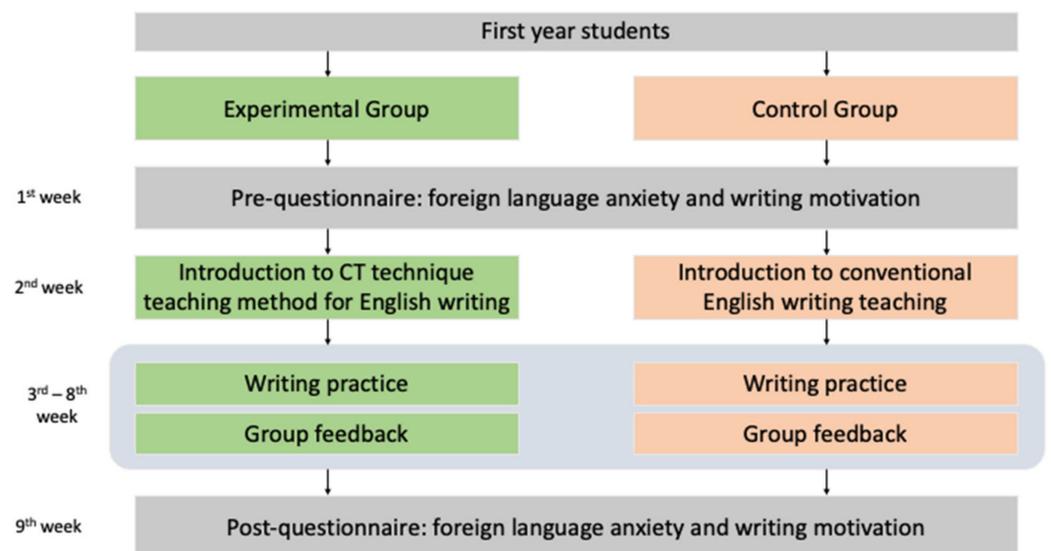


Figure 1. Experimental procedure.



**Figure 2.** Students carried out writing and discussion activities.

The control group was instructed using conventional teacher-centered instruction, where the teacher was the main source of control during the writing process. The activities in the control group include the traditional lecture on grammar, traditional writing exercises they need to complete, and peer review. The activities in the control group follow what typically happens in a classroom setting.

The instruction of the experimental group was designed based on the fundamental concepts of CT to improve the students' English writing anxiety and motivation through their accomplishment of a series of writing tasks. The design was intended to engage students in the learning process rather than focus on the learning product. The students were expected to be able to: (1) Recognize and implement the appropriate steps in the writing process; (2) Employ clauses and phrases to change sentence structures; (3) Develop ideas and content with specific details; and (4) Adhere to grammatical rules.

The fundamental concepts of CT were divided into the following steps: (1) Decomposition through brainstorming, where topics and ideas are broken down into smaller parts; (2) Pattern recognition, where underlying patterns are identified through the visualization of key points; (3) Abstraction, where sentences and paragraphs are composed using existing knowledge; (4) Algorithm, where key ideas are elaborated on through additional explanation and illustration; and (5) Evaluation, where writing is subjected to peer evaluation. The experimental group's training activities are detailed in Table 1.

**Table 1.** Experimental group teaching activities.

Fundamental Concepts of CT	Activities	Timing
Decomposition	<p>Without critiquing one another, students are encouraged to contribute ideas simultaneously about how to complete the assigned tasks.</p> <ul style="list-style-type: none"> <li>- Break down the topic into small parts.</li> <li>- Generate ideas and key points about each part of a topic.</li> </ul> <p>Students develop potential angles and points of view to explore.</p>	10 min
Pattern recognition	<ul style="list-style-type: none"> <li>- Identify the underlying structure of a sentence.</li> <li>- Visually organize the key points.</li> <li>- Connect ideas to support a broader argument.</li> <li>- Explore the directions of the writing process.</li> <li>- Focus on the forms of verbs and predicates.</li> </ul> <p>Students utilize their existing knowledge of English.</p>	10 min
Abstraction	<ul style="list-style-type: none"> <li>- Employ related adverbs, conjunctions, pronouns, and prepositions.</li> <li>- Use related vocabulary.</li> </ul> <p>Students explain the key points in an organized and structured manner by providing evidence to support each key point.</p>	10 min
Algorithm	<ul style="list-style-type: none"> <li>- State the main idea of a sentence.</li> <li>- Provide detailed support and examples.</li> <li>- Explain the relationship between the key point and any illustrated examples.</li> </ul> <p>Students are encouraged to evaluate other's work.</p>	10 min
Evaluation	<ul style="list-style-type: none"> <li>- Offer positive and constructive feedback.</li> <li>- Discuss how students can use this feedback to improve their work.</li> </ul>	10 min

### 3.4. Measuring Instruments

This study adapted several self-assessment questionnaires, including those related to EFL writing anxiety and motivation, to observe the effectiveness of the fundamental concepts of CT in influencing writing anxiety and motivation. The questionnaires were graded on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

#### 3.4.1. Writing Anxiety

The students' writing anxiety was measured using the SLWAI developed by [22]. The SLWAI is divided into three categories and consists of 22 items, namely eight items for cognitive anxiety (negative expectation of performance; e.g., while writing English compositions, I feel worried and uneasy if I know they will be evaluated), seven items for somatic anxiety (negative physical feelings, such as anxiousness and tension; e.g., my mind often goes blank when I start to work on an English composition), and seven items for avoidance behavior (avoidance of writing tasks; e.g., I do my best to avoid situations in which I have to write in English). Positively phrased items indicated the presence of anxiousness, whereas negatively phrased items indicated contentment with writing; reverse scoring was required before total scores could be calculated. A higher ratio indicated greater English writing anxiety. Table 2 lists the scale reliabilities and validity of writing anxiety. The Cronbach's  $\alpha$  reliability coefficients of the three components were between 0.702 to 0.749 in the pretest, and between 0.799 to 0.867 in the posttest. As shown in Table 2, the validity test of the Pearson correlation shows that all subcomponents of writing anxiety had strong correlations. Therefore, all three dimensions were reliable and valid for measuring writing anxiety.

**Table 2.** Writing anxiety and motivation scales' reliability and validity.

Scale	Cronbach's $\alpha$		Pearson Correlation	
	Pretest	Posttest	Pretest	Posttest
Cognitive anxiety	0.723	0.839	0.667 **	0.919 **
Somatic anxiety	0.702	0.799	0.661 **	0.776 **
Avoidance behavior	0.794	0.867	0.645 **	0.852 **
Self-efficacy beliefs	0.701	0.882	0.569 **	0.861 **
Mastery goals	0.805	0.864	0.803 **	0.910 **
Performance goals	0.736	0.846	0.564 **	0.772 **

\*\*  $p = 0.01$ .

### 3.4.2. Writing Motivation

The WTM tool developed by [49] was employed to measure the students' writing motivation before and after the course. Writing motivation was divided into three categories for measurement, namely self-efficacy beliefs (ten items), mastery goals (four items), and performance goals (five items). Self-efficacy beliefs refer to students' ability to drive themselves to complete tasks (e.g., I expect myself to write a good draft), mastery goals refer to students' motivation to acquire knowledge and skills (e.g., I want to learn as much as possible from this course), and performance goals refer to students' being extrinsically motivated to outperform other students (e.g., I want to write a good draft, to show others my skill). Table 2 lists the scale reliabilities and validity of writing motivation. The Cronbach's  $\alpha$  coefficient of the three categories of writing motivation is well beyond the 0.7 acceptable level of reliability both in pretest and posttest. The Pearson correlation results for the validity test in Table 2 show that all subcategories of writing motivation had strong correlations. These results suggested that the questionnaire was a reliable and valid measurement of writing motivation.

### 3.5. Data Analysis

The data gathered through the pretest and posttest questionnaires were analyzed using SPSS 25.0 (Chicago, IL, USA). Descriptive analysis (normality, mean score, and standard deviation) and an analysis of covariance (ANCOVA) were performed to assess the differences in writing anxiety and motivation between the two groups. This study used an ANCOVA to determine the influence of the fundamental concepts of CT on writing anxiety and motivation in order to evaluate the effects of the treatment statistically.

The assumptions of the normality test were performed on the data before the statistical tests. The writing anxiety subscales of cognitive anxiety ( $s = 0.974$ ,  $p = 0.237$ ), somatic anxiety ( $s = 0.981$ ,  $p = 0.508$ ), and avoidance behavior ( $s = 0.965$ ,  $p = 0.088$ ) had normal distributions. The writing motivation subscales of self-efficacy beliefs ( $s = 0.969$ ,  $p = 0.136$ ), mastery goals ( $s = 0.987$ ,  $p = 0.803$ ), and performance goals ( $s = 0.971$ ,  $p = 0.185$ ) were also normally distributed.

## 4. Results

### 4.1. Writing Anxiety

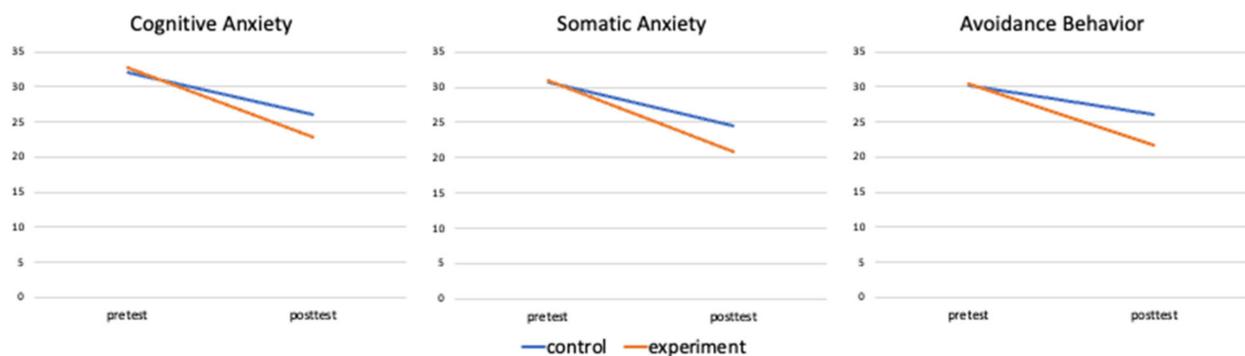
The descriptive and ANCOVA results of the writing anxiety categories are summarized in Tables 3 and 4. The changes in the writing anxiety categories pretest and posttest are visually presented in Figure 3. The descriptive results of the posttest revealed that the students in the experimental group ( $M = 22.9$ ,  $SD = 4.01$ ) had less cognitive anxiety than their counterparts in the control group ( $M = 26.1$ ,  $SD = 6.96$ ). Furthermore, a statistically significant difference in the cognitive anxiety posttest ( $F = 5.56$ ,  $p < 0.05$ ,  $\eta^2 = 0.092$ ) between the two groups was noted after the pretest scores had been controlled for. This finding suggested that the H1a hypothesis in this study can be supported.

**Table 3.** Descriptive results of students' writing anxiety.

Variable	Control Group				Experimental Group				Mean Differences
	Pretest		Posttest		Pretest		Posttest		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Cognitive anxiety	32.1	3.55	26.1	6.96	32.8	3.73	22.9	4.01	−3.2
Somatic anxiety	30.6	3.35	24.5	5.69	31.0	2.76	20.8	2.97	−3.7
Avoidance behavior	30.2	2.81	26.0	5.04	30.5	2.23	21.7	6.32	−4.3

**Table 4.** ANCOVA results of students' writing anxiety.

Variable	SS	<i>df</i>	Mean Square	<i>F</i>	<i>p</i>	Partial $\eta^2$
Cognitive anxiety	169	1	169.2	5.56	0.022 *	0.092
Somatic anxiety	207.3	1	207.3	10.006	0.003 *	0.154
Avoidance behavior	260.4	1	260.4	8.12	0.006 *	0.129

\**p* < 0.05.**Figure 3.** The changes in writing anxiety subscales.

The descriptive results of the posttest revealed that the students in the control group ( $M = 24.5$ ,  $SD = 5.69$ ) had higher levels of somatic anxiety than those in the experimental group ( $M = 20.8$ ,  $SD = 2.97$ ). The ANCOVA analysis verified that these changes in the students' somatic anxiety posttest were statistically significant ( $F = 10.006$ ,  $p < 0.05$ ,  $\eta^2 = 0.154$ ). The results indicated that the H1b hypothesis could be supported.

Regarding the students' avoidance behavior, the posttest mean score indicated that the experimental group ( $M = 21.7$ ,  $SD = 6.32$ ) exhibited lower degrees of avoidance behavior than the control group ( $M = 26.0$ ,  $SD = 5.04$ ). The ANCOVA results revealed a statistically significant difference in avoidance behavior between the two groups after controlling the pretest score ( $F = 8.12$ ,  $p < 0.05$ ,  $\eta^2 = 0.129$ ). This means that the H1c hypothesis of this study is supported.

#### 4.2. Writing Motivation

The results of the descriptive and ANCOVA analysis of the writing motivation categories were presented in Tables 5 and 6. Figure 4 illustrates the changes in the students' writing motivation categories according to the pretest and posttest scores. For self-efficacy beliefs, the posttest scores of the experimental group ( $M = 4.12$ ,  $SD = 0.512$ ) were higher than those of the control group ( $M = 3.27$ ,  $SD = 0.482$ ). Furthermore, the analysis results indicated a significant difference in the students' self-efficacy beliefs posttest ( $F = 44.29$ ,  $p < 0.05$ ,  $\eta^2 = 0.442$ ) between the two groups after controlling the pretest. Therefore, supporting the H2a hypothesis.

**Table 5.** Descriptive results of students' motivation.

Variable	Control Group				Experimental Group				Mean Differences
	Pretest		Posttest		Pretest		Posttest		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Self-efficacy beliefs	3.02	0.475	3.27	0.482	3.01	0.486	4.12	0.521	0.85
Mastery goals	3.16	0.595	3.55	0.727	3.54	0.710	4.72	0.345	1.17
Performance goals	3.12	0.525	3.83	0.475	3.28	0.544	4.66	0.427	0.83

**Table 6.** ANCOVA of students' motivation.

Variable	SS	<i>df</i>	Mean Square	<i>F</i>	<i>p</i>	Partial $\eta^2$
Self-efficacy beliefs	10.47	1	10.468	44.29	0.001 *	0.446
Mastery goals	19.642	1	19.642	60.94	0.001 *	0.526
Performance goals	9.7543	1	9.7543	47.129	0.001 *	0.461

\**p* < 0.05.**Figure 4.** The changes in motivation subscales.

Regarding mastery goals, the descriptive results indicated that the experimental group ( $M = 4.72$ ,  $SD = 0.345$ ) had higher posttest scores than did the control group ( $M = 3.55$ ,  $SD = 0.727$ ). Moreover, the ANCOVA results revealed a significant difference between the two groups' posttest, after controlling the pretest ( $F = 60.94$ ,  $p < 0.05$ ,  $\eta^2 = 0.426$ ). The results indicated that the H2b hypothesis is supported.

Regarding performance goals, the descriptive results revealed that the control group had lower posttest scores ( $M = 3.83$ ,  $SD = 0.475$ ) than the experimental group ( $M = 4.66$ ,  $SD = 0.427$ ). The ANCOVA results revealed that these differences in the posttest were statistically significant ( $F = 47.129$ ,  $p < 0.05$ ,  $\eta^2 = 0.461$ ). Therefore, the H2c hypothesis in this study is supported.

## 5. Discussion and Implications

As mentioned, this study employed a quasi-experiment design to determine the influence of the fundamental concepts of CT in reducing writing anxiety and increasing writing motivation among EFL students.

### 5.1. Influence of the Fundamental Concepts of CT in Reducing Students' Writing Anxiety

This study's first research question concerned the effectiveness of the fundamental concepts of CT in reducing K-12 students' anxiety toward writing. The results of this study revealed that the fundamental concepts of CT were able to reduce the students' cognitive anxiety, somatic anxiety, and avoidance behavior more than they did in a conventional teaching method. Therefore, applying the fundamental concepts of CT to K-12 English writing courses could increase the optimism of the students regarding their writing assignments, which reduces the overall students' writing anxiety. This finding is in line with that

of [4], which reported that incorporating the fundamental concepts of CT into language instruction can reduce language learning anxiety. In addition, the significant reduction in the experimental group's writing anxiety provided evidence that CT is essential to mitigating the negative effects of writing anxiety.

Incorporating the fundamental concepts of CT into English writing courses can reduce students' writing anxiety. This could be due to the fact that decomposition enables students to divide writing assignments into smaller steps that are perceived as more manageable. This can help students foster a sense of control and accomplishment in their ability to complete writing assignments, thereby reducing writing anxiety. Pattern recognition assists students in recognizing grammatical, structural, and organizational patterns. Teaching students how to recognize patterns through planning, brainstorming, and revising can help students feel more confident in learning to write effectively and efficiently. Abstraction teaches students to focus on the key ideas and concepts of the writing assignments, which can help students prioritize what to include in their writing, making the task less overwhelming. Step-by-step algorithmic thinking assists students in organizing the components of their writing. Thus, the students can follow a structured writing process and make the writing feel more manageable, thereby increasing the self-perception of being organized. Evaluation in writing means reviewing and analyzing the writing drafts to identify areas for improvement. This provides students with feedback on their writing, assisting them in identifying areas for improvement and increasing confidence in their writing skills.

The results of this study support those of [20,24,52], whose findings suggest that following CT instruction may be associated with lower writing anxiety, which could potentially be related to positive emotions experienced by individuals. Writing anxiety encompasses cognitive, physiological, and behavioral influences on students' writing. In the present study, the influence of the fundamental concepts of CT was most significant for somatic anxiety, followed by avoidance behavior and then cognitive anxiety. During the English writing course, the students exposed to the fundamental concepts of CT could analyze the key points of writing tasks and provide detailed examples, thereby gaining more confidence in their writing capabilities and lowering their somatic anxiety. In terms of avoidance behavior, the students in the experimental group were engaged in the experimental activities and assisted one another with feedback and evaluation. Hence, the fundamental concepts of CT suppress avoidance behavior induced through anxiety. CT instruction guided the students in using brainstorming and in organizing their writing, thereby increasing their writing confidence and mitigating their cognitive anxiety.

### *5.2. Influence of the Fundamental Concepts of CT in Improving Students' Motivation*

This study's second research question concerned the impact of using the fundamental concepts of CT to enhance students' writing motivation. The results of this study revealed that the fundamental concepts of CT enhanced students' writing motivation in terms of self-efficacy beliefs, mastery goals, and performance goals more effectively than the conventional teaching method. The results of this study are consistent with those of [4,27], who have reported a significant positive relationship between CT and motivation. Moreover, the activities of the conventional teaching method were found to be less motivating. They did not stimulate the student to break down the problems they faced, unlike the experimental group, in which they were required to break down problems, brainstorm ideas, recognize the pattern, and organize the key points. Regarding the writing motivation subcategories, the effect of the fundamental concepts of CT was strongest for mastery goals, followed by performance goals, and then self-efficacy beliefs.

The decomposition activities of brainstorming ideas and breaking down the writing process into small, more manageable steps promotes students' motivation to complete English writing assignments. Pattern recognition encourages students to understand the fundamental patterns that underlie the writing process. Teaching general writing strategies to students that can be applied to any writing assignment boosts their confidence and motivation to complete writing tasks. Additionally, recognizing patterns and memorizing

them enables students to identify areas in which they must improve to become outstanding writers. Abstraction supports students in comprehending the underlying principles of effective writing, which increases their motivation to complete tasks. Abstraction also includes teaching students about the structure of a well-written essay, the critical use of evidence to support their ideas, and the crucial roles of grammar and punctuation. Algorithmic thinking represents a step-by-step approach to organizing key points that increases students' motivation to complete tasks. Finally, evaluation provides students with constructive criticism and suggestions for improving their writing, which in turn triggers their motivation to complete tasks.

Incorporating the fundamental concepts of CT in English writing enables the exercise of participants' critical thinking and develops a deeper understanding of complex issues [18,51]. The ability to think critically in writing is particularly important for sustainable development [6,18]. It enables students to effectively communicate their ideas, engage in constructive criticism, and work toward a sustainable world. Through the CT concepts, students are better equipped to identify and tackle complex challenges in their communities and engage in lifelong learning, contributing to a more sustainable future.

### *5.3. Implications of the Study*

This study suggests that the incorporation of the fundamental concepts of CT into English writing can have a positive impact on students' writing motivation and anxiety levels, and provide practical implications for teachers and policymakers alike. Teachers can enhance students' writing by integrating the fundamental concepts of CT, such as decomposition, pattern recognition, abstraction, algorithmic thinking, and evaluation, to promote structured and organized writing. The integration of CT in writing instructions has been found to improve students' writing and motivation, and reduce writing anxiety [4,39]. Policymakers can further support the integration of the fundamental concepts of CT into K12 curricula by providing funding for teacher training, curriculum development, and resources to implement this learning approach. Professional development opportunities for teachers to learn about CT and its integration into writing instruction can support the successful implementation of this learning approach. Additionally, resources, such as peer tutoring and writing support, which are available to students who experience writing anxiety, improve their engagement and motivation to write.

## **6. Conclusions and Limitation**

This study demonstrated that employing the fundamental concepts of CT in writing classes can guide students to adopt a more planned and structured approach to English writing. By breaking down the writing process into small, manageable steps, students can feel more confident in their ability to complete writing tasks and more motivated to do so; these changes reduce anxiety because they enable students to feel more in control of the process. Additionally, after breaking down tasks into smaller, more manageable steps, students can perceive a sense of accomplishment with their completion of each step and the resultant advancement toward their goal. The quasi-experimental design of this study verified that incorporating CT into English writing classes improved students' motivation and reduced students' anxiety toward writing in English.

The application of CT to reduce students' writing anxiety and improve their writing motivation in English writing classes could include teaching students how to divide tasks into manageable steps, identifying the key elements of a writing task, developing an outline for their writing, and using algorithms and heuristics to identify and correct errors in their writing. Students must be taught techniques to manage their anxiety, such as relaxation techniques, positive self-talk, and goal setting, to reduce writing anxiety. In addition, students need opportunities to practice writing and receive feedback to develop their confidence. When receiving feedback, instead of simply accepting or rejecting feedback, students should critically think about the reasoning behind the feedback and how it can

improve their goals and values. By acquiring these skills, students can become confident and motivated in their writing and less anxious about the writing process.

Incorporating computational thinking in an English composition course requires a certain level of technical understanding. Many K-12 students may lack the skills and background knowledge necessary to apply computational thinking to their writing effectively. In addition, it may be challenging to motivate students to use computational thinking if they are unfamiliar with the concept or do not see how it can benefit their writing. Teachers can employ a variety of strategies to motivate students, such as providing rewards for task completion, providing feedback on student work, and engaging students in interactive activities. To further motivate students, teachers should consider incorporating computational thinking into other subjects, such as mathematics and science.

The quasi-experimental design can be useful for evaluating the effectiveness of interventions, in this study, the application of CT to English writing. However, this study has some limitations. First, there are sample size limitations, which can limit the generalization of the results. Second, there is limited external validity; due to the controlled environment, the findings may not be representative and may not be applicable to different contexts. Third, the duration of the experiment activity is a limitation and there is a possibility that the novelty of the teaching may generate curiosity among students. Despite the limitations of this study, the findings provide valuable and meaningful insights into the current research problems. Therefore, for future studies, it is advisable to increase the number of participants and implement the fundamental concepts of CT in different contexts of language acquisition. To address the limitation of the duration of the experiment activity, future research could explore the long-term effects of the fundamental concepts of CT on students' writing anxiety and motivation. In future research, it would be valuable to investigate which components of CT are most effective in reducing writing anxiety and improving writing motivation. Addressing how the fundamental concepts of CT can be adapted to suit the needs of different students and contexts would provide valuable insights into how CT can support students' learning.

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## References

1. Grabe, W.; Kaplan, R.B. Theory and Practice of Writing: An Applied Linguistic Perspective. *Coll. Compos. Commun.* **1998**, *49*, 301. [[CrossRef](#)]
2. Kao, C.W.; Reynolds, B.L. A Study on the Relationship among Taiwanese College Students' EFL Writing Strategy Use, Writing Ability and Writing Difficulty. *Engl. Teach. Learn.* **2017**, *41*, 31–67.
3. Kırmızı, Ö.; Kırmızı, G.D. An Investigation of L2 Learners' Writing Self-Efficacy, Writing Anxiety and Its Causes at Higher Education in Turkey. *Int. J. High. Educ.* **2015**, *4*, 57. [[CrossRef](#)]
4. Parsazadeh, N.; Cheng, P.-Y.; Wu, T.-T.; Huang, Y.-M. Integrating Computational Thinking Concept Into Digital Storytelling to Improve Learners' Motivation and Performance. *J. Educ. Comput. Res.* **2020**, *59*, 470–495. [[CrossRef](#)]

5. Hsu, T.-C.; Chang, S.-C.; Hung, Y.-T. How to learn and how to teach computational thinking: Suggestions based on a review of the literature. *Comput. Educ.* **2018**, *126*, 296–310. [[CrossRef](#)]
6. He, Z.; Wu, X.; Wang, Q.; Huang, C. Developing Eighth-Grade Students' Computational Thinking with Critical Reflection. *Sustainability* **2021**, *13*, 11192. [[CrossRef](#)]
7. Hunsaker, E. The K-12 Educational Technology Handbook 1 2.3 Computational Thinking Learning Objectives. 2018. Available online: [https://edtechbooks.org/k12handbook/computational\\_thinking](https://edtechbooks.org/k12handbook/computational_thinking) (accessed on 29 January 2023).
8. Yadav, A.; Hong, H.; Stephenson, C. Computational Thinking for All: Pedagogical Approaches to Embedding 21st Century Problem Solving in K-12 Classrooms. *Techtrends* **2016**, *60*, 565–568. [[CrossRef](#)]
9. Sabitzer, B.; Demarle-Meusel, H.; Jarnig, M. Computational Thinking through Modeling in Language Lessons. In Proceedings of the IEEE Global Engineering Education Conference, EDUCON, Santa Cruz de Tenerife, Spain, 17–20 April 2018.
10. Wing, J.M. Computational Thinking. *Commun. ACM* **2006**, *49*, 33–35. [[CrossRef](#)]
11. Wing, J.M. Computational thinking and thinking about computing. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.* **2008**, *366*, 3717–3725. [[CrossRef](#)]
12. Kale, U.; Akcaoglu, M.; Cullen, T.; Goh, D.; Devine, L.; Calvert, N.; Grise, K. Computational What? Relating Computational Thinking to Teaching. *Techtrends* **2018**, *62*, 574–584. [[CrossRef](#)]
13. Lin, J.-M.; Hong, Z.-W.; Song, Z.-K.; Shen, W.-W.; Cheng, W.-K. Improve University Humanities Students' Problem-Solving Ability Through Computational Thinking Training. In Proceedings of the Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), Virtual Event, 29 November–1 December 2021; Volume 13117 LNCS, pp. 131–143.
14. Brackmann, C.P.; Román-González, M.; Robles, G.; Moreno-León, J.; Casali, A.; Barone, D. Development of Computational Thinking Skills through Unplugged Activities in Primary School. In Proceedings of the 12th Workshop on Primary and Secondary Computing Education, Nijmegen, The Netherlands, 8 November 2017. [[CrossRef](#)]
15. Lee, M.; Lee, J. Enhancing computational thinking skills in informatics in secondary education: The case of South Korea. *Educ. Technol. Res. Dev.* **2021**, *69*, 2869–2893. [[CrossRef](#)]
16. Sengupta, P.; Kinnebrew, J.S.; Basu, S.; Biswas, G.; Clark, D. Integrating computational thinking with K-12 science education using agent-based computation: A theoretical framework. *Educ. Inf. Technol.* **2013**, *18*, 351–380. [[CrossRef](#)]
17. Grover, S.; Pea, R. Computational Thinking in K-12: A Review of the State of the Field. *Educ. Res.* **2013**, *42*, 38–43. [[CrossRef](#)]
18. Jong, M.S.-Y.; Geng, J.; Chai, C.S.; Lin, P.-Y. Development and Predictive Validity of the Computational Thinking Disposition Questionnaire. *Sustainability* **2020**, *12*, 4459. [[CrossRef](#)]
19. Gok, D.; Bozoglan, H.; Bozoglan, B. Effects of online flipped classroom on foreign language classroom anxiety and reading anxiety. *Comput. Assist. Lang. Learn.* **2021**, 1–21. [[CrossRef](#)]
20. Ho, M.-C. Exploring Writing Anxiety and Self-Efficacy among EFL Graduate Students in Taiwan. *High. Educ. Stud.* **2015**, *6*, 24. [[CrossRef](#)]
21. Horwitz, E.K.; Horwitz, M.B.; Cope, J. Foreign Language Classroom Anxiety. *Mod. Lang. J.* **1986**, *70*, 125. [[CrossRef](#)]
22. Cheng, Y.-S. A measure of second language writing anxiety: Scale development and preliminary validation. *J. Second. Lang. Writ.* **2004**, *13*, 313–335. [[CrossRef](#)]
23. Liu, H.J. Understanding EFL Undergraduate Anxiety in Relation to Motivation, Autonomy, and Language Proficiency. *Electron. J. Foreign Lang. Teach.* **2012**, *9*, 123–139.
24. Sabti, A.; Rashid, S.; Nimehchisalem, V.; Darmi, R. The Impact of Writing Anxiety, Writing Achievement Motivation, and Writing Self-Efficacy on Writing Performance: A Correlational Study of Iraqi Tertiary EFL Learners. *SAGE Open* **2019**, *9*, 1–13. [[CrossRef](#)]
25. Rahimi, M.; Fathi, J. Exploring the impact of wiki-mediated collaborative writing on EFL students' writing performance, writing self-regulation, and writing self-efficacy: A mixed methods study. *Comput. Assist. Lang. Learn.* **2021**, *35*, 2627–2674. [[CrossRef](#)]
26. Wright, K.L.; Hodges, T.S.; Dismuke, S.; Boedeker, P. Writing Motivation and Middle School: An Examination of Changes in Students' Motivation for Writing. *Lit. Res. Instr.* **2020**, *59*, 148–168. [[CrossRef](#)]
27. Martín, J.; Hamelers, I.; Trujillo-Torres, J.-M.; Moreno-Guerrero, A.-J. A Comparison between Collaborative and Individual Writings in Promoting Motivation and Language Acquisition. *Sustainability* **2020**, *12*, 7959. [[CrossRef](#)]
28. Kwon, J.; Kim, J. A Study on the Design and Effect of Computational Thinking and Software Education. *KSII Trans. Internet Inf. Syst.* **2018**, *12*, 4057–4071. [[CrossRef](#)]
29. Jacob, S.; Nguyen, H.; Tofel-grehl, C.; Richardson, D.; Warschauer, M. Teaching Computational Thinking to English Learners. *NYS Tesol J.* **2018**, *5*, 12–24.
30. Rottenhofer, M.; Sabitzer, B.; Rankin, T. Developing Computational Thinking Skills Through Modeling in Language Lessons. *Open Educ. Stud.* **2021**, *3*, 17–25. [[CrossRef](#)]
31. Korkmaz, Ö.; Çakir, R.; Özden, M.Y. A validity and reliability study of the computational thinking scales (CTS). *Comput. Hum. Behav.* **2017**, *72*, 558–569. [[CrossRef](#)]
32. Tsai, M.-J.; Liang, J.-C.; Lee, S.W.-Y.; Hsu, C.-Y. Structural Validation for the Developmental Model of Computational Thinking. *J. Educ. Comput. Res.* **2021**, *60*, 56–73. [[CrossRef](#)]
33. Wright, K.L.; Hodges, T.S.; McTigue, E.M. A validation program for the Self-Beliefs, Writing-Beliefs, and Attitude Survey: A measure of adolescents' motivation toward writing. *Assess. Writ.* **2018**, *39*, 64–78. [[CrossRef](#)]

34. Chien, S.-C. Students' use of writing strategies and their English writing achievements in Taiwan. *Asia Pac. J. Educ.* **2012**, *32*, 93–112. [CrossRef]
35. Reynolds, B.L. Helping Taiwanese Graduate Students Help Themselves: Applying Corpora to Industrial Management English as a Foreign Language Academic Reading and Writing. *Comput. Sch.* **2015**, *32*, 300–317. [CrossRef]
36. Hunsaker, E. Computational Thinking. In *The K-12 Educational Technology Handbook*; Ottenbreit-Leftwich, A., Kimmons, R., Eds.; BYU Open Textbook Network: 2018. Available online: <https://edtechbooks.org/k12handbook> (accessed on 21 December 2022).
37. Fronza, I.; Gallo, D. Towards Mobile Assisted Language Learning Based on Computational Thinking. In Proceedings of the Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), Rome, Italy, 26–29 October 2016; Volume 10013 LNCS, pp. 141–150.
38. Vogel, S.; Hoadley, C.; Ascenzi-Moreno, L.; Menken, K. The Role of Translanguaging in Computational Literacies. In Proceedings of the 50th ACM Technical Symposium on Computer Science Education, Minneapolis, MN, USA, 22 February 2019; ACM: New York, NY, USA, 2019; pp. 1164–1170.
39. Youjun, T.; Xiaomei, M. Computational thinking: A mediation tool and higher-order thinking for linking EFL grammar knowledge with competency. *Think. Ski. Creativity* **2022**, *46*, 101143. [CrossRef]
40. Liao, Y.-H.; Chen, Y.-L.; Chen, H.-C.; Chang, Y.-L. Infusing creative pedagogy into an English as a foreign language classroom: Learning performance, creativity, and motivation. *Think. Ski. Creat.* **2018**, *29*, 213–223. [CrossRef]
41. Ghaffar, M.A.; Khairallah, M.; Salloum, S. Co-constructed rubrics and assessment for learning: The impact on middle school students' attitudes and writing skills. *Assess. Writ.* **2020**, *45*, 100468. [CrossRef]
42. Barr, V.; Stephenson, C. Bringing Computational Thinking to K-12: What Is Involved and What Is the Role of the Computer Science Education Community? *ACM Inroads* **2011**, *2*, 48–54. [CrossRef]
43. Gardner, R.C. The Role of Attitudes and Motivation. In *Social Psychology and Second Language Learning*; Wiley: Chichester, UK, 1985.
44. Lu, D.; Xie, Y. The effects of a critical thinking oriented instructional pattern in a tertiary EFL argumentative writing course. *High. Educ. Res. Dev.* **2019**, *38*, 969–984. [CrossRef]
45. Yaqi, F.; Xiaoli, Z. The Effect of Collaborative Writing Mode of Thinking Visualization on EFL Writing Anxiety of Junior High School Students. In Proceedings of the International Conference for Media in Education, Palma, Spain, 4–6 July 2022.
46. Wang, Y.; Luo, X.; Liu, C.-C.; Tu, Y.-F.; Wang, N. An Integrated Automatic Writing Evaluation and SVVR Approach to Improve Students' EFL Writing Performance. *Sustainability* **2022**, *14*, 11586. [CrossRef]
47. Daly, J.A.; Miller, M.D. The Empirical Development of an Instrument to Measure Writing Apprehension. *Res. Teach. Engl.* **1975**, *9*, 242–249.
48. Dörnyei, Z. *The Psychology of the Language Learner: Individual Differences in Second Language Acquisition*; Routledge: London, UK, 2014.
49. Duijnhouwer, H.; Prins, F.; Stokking, K.M. Feedback providing improvement strategies and reflection on feedback use: Effects on students' writing motivation, process, and performance. *Learn. Instr.* **2012**, *22*, 171–184. [CrossRef]
50. Wei, M. The Interrelatedness of Affective Factors in EFL Learning: An Examination of Motivational Patterns in Relation to Anxiety in China. *Tesol-Ej* **2007**, *11*, n1.
51. Voogt, J.; Fisser, P.; Good, J.; Mishra, P.; Yadav, A. Computational thinking in compulsory education: Towards an agenda for research and practice. *Educ. Inf. Technol.* **2015**, *20*, 715–728. [CrossRef]
52. Jin, Y.; Dewaele, J.-M.; MacIntyre, P.D. Reducing anxiety in the foreign language classroom: A positive psychology approach. *System* **2021**, *101*, 102604. [CrossRef]

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