

# INTEGRATING COMPUTATIONAL THINKING CONCEPTS INTO WEB-BASED COLLABORATIVE ENGLISH AS A FOREIGN LANGUAGE WRITING

Hasan Selcuk<sup>1</sup>, Linda Daniela<sup>1</sup>

<sup>1</sup>University of Latvia, Latvia

## ABSTRACT

This qualitative study explores the integration of Computational Thinking (CT) concepts in web-based collaborative writing (CW) within English as a Foreign Language (EFL) instruction. It investigates how CT concepts, including decomposition, pattern recognition, abstraction, and algorithmic thinking, enhance teaching strategies and foster learner engagement in digital writing environments. Data collection involved a workshop with EFL teachers ( $N = 7$ ) on applying CT concepts in web-based CW, followed by a focus group interview and reflective journal entries documenting their teaching practices. The findings suggest that incorporating CT principles into CW tasks enables students to break down complex writing processes, identify linguistic patterns, and systematically structure their contributions. Teachers observed notable improvements in students' coherence, clarity, and critical thinking, as well as enhanced collaboration through digital platforms. However, they also highlighted challenges such as limited access to user-friendly tools and the need for further professional development in web-based foreign language writing pedagogy. This study provides valuable insights into interdisciplinary EFL instruction by demonstrating how CT principles can enrich CW practices. By fostering structured, reflective, and technology-enhanced learning environments, CT integration equips students with essential 21st-century skills for language education. Additionally, the findings contribute to discussions on teacher professionalism and education for the future, highlighting the need for educators to develop digital competencies and adapt to evolving pedagogical landscapes.

**Keywords:** *Computational Thinking; Collaborative Writing; EFL Instruction; Digital Literacy; Teacher Professional Development*

## Introduction

In recent years, technology-enhanced language learning has brought new opportunities to foreign language instruction, particularly through web-based collaborative writing (CW). This approach enables learners to co-construct texts in digital environments, facilitating real time interaction, peer feedback and collaborative revision processes that

contribute to both linguistic development and critical thinking (Pardede, 2024; Selcuk & Daniela, 2023; Selcuk, et al., 2019; Storch, 2019). At the same time, Computational Thinking (CT), originally conceptualised within computer science, has emerged as an essential twenty-first century competence with potential applications across multiple educational domains, including language education (UNESCO, 2021; Wing, 2006). CT principles, such as *decomposition*, *pattern recognition*, *abstraction* and *algorithmic thinking*, offer structured cognitive frameworks that can support the complex processes involved in language learning and writing (Gu et al., 2025; Peng et al., 2023).

Although both CW and CT have been widely discussed for their individual pedagogical merits, limited empirical research exists on how these two approaches may be integrated to mutually enhance writing instruction, particularly within the context of secondary English as a Foreign Language (EFL) classrooms. As highlighted by Wu et al. (2024) and Yu et al. (2024), much of the current research on CT in language education focuses on individual learners, while studies on web-based CW largely examine collaborative outcomes without incorporating explicit CT strategies (Jeong, 2016; Li, 2023). Despite growing research on both CT and CW in language education, empirical studies examining their combined implementation in collaborative EFL writing remain scarce, particularly at the secondary school level.

Addressing this gap, the present study investigates how CT concepts can be integrated into web-based CW tasks within EFL instruction. By exploring the experiences of secondary school EFL teachers who applied CT-informed CW activities in their classrooms, this research aims to contribute to the emerging discussion on interdisciplinary approaches that combine cognitive, linguistic and digital competencies in language education.

## Literature Review

In recent years, technology-enhanced learning (TEL) has played a growing role in reshaping pedagogical practices across disciplines, including language education (Daniela et al., 2018). Sustainable higher education requires flexible, digital, and student-centred teaching approaches, making the integration of CT into EFL instruction both timely and relevant. To provide a foundation for this study, the following review examines relevant literature on web-based CW in EFL contexts, the role of CT in language education, and their potential integration.

### Web-Based Collaborative Writing in EFL Contexts

Web-based CW has become an increasingly popular pedagogical approach in EFL instruction due to its capacity to foster learner interaction, peer support and shared authorship through digital platforms such as Google Docs and wikis (Storch, 2019). These tools enable students to co-construct texts in real time, offering opportunities for mutual feedback, negotiation of meaning and collaborative problem solving. Empirical studies have consistently demonstrated the positive outcomes of web-based CW for improving writing performance, learner autonomy and motivation.

For example, Jeong (2016) reported that Korean EFL students using Google Docs exhibited enhanced communication, autonomous participation and dynamic peer collaboration, while Li (2023) found that Chinese EFL learners involved in online collaborative writing demonstrated improved writing performance, motivation and self-efficacy. These studies underscore the value of CW in creating learner-centred, interactive writing environments that promote both linguistic and socio-cognitive development. Furthermore, Pardede (2024) and Zhang and Chen (2022) emphasised the role of CW in enhancing syntactic complexity, text accuracy and language fluency, particularly when peer-mediated support structures are embedded within writing activities.

## Computational Thinking in Language Education

Computational Thinking (CT), initially proposed by Wing (2006), refers to a set of problem-solving skills that involve decomposing complex tasks, identifying patterns, abstracting key information and applying algorithmic thinking. While CT originated within computer science, its relevance has expanded across disciplines as an essential twenty-first century competence (UNESCO, 2021). In language education, CT offers a structured cognitive framework that can support the planning, organisation and revision processes inherent to writing tasks.

Several recent studies have explored the application of CT in foreign language contexts. Yu et al. (2024) conducted a systematic review demonstrating that CT-oriented strategies can enhance grammar learning, text coherence and higher-order thinking in language learners. Similarly, Wu et al. (2024) implemented CT-based writing instruction that taught students to approach writing tasks like debugging code, resulting in improvements in both writing quality and critical thinking. Černochová and Selcuk (2022) further illustrated the growing awareness of CT's cross-disciplinary applicability, as future language teachers increasingly recognise its relevance to instructional design.

## Integrating Computational Thinking with Web-Based Collaborative Writing

Although both CT and collaborative writing offer substantial pedagogical benefits independently, research on their combined integration remains underdeveloped. Most existing CT studies focus on individual learners' problem solving or linguistic accuracy (Wu et al., 2024; Tang & Ma, 2024), while studies on web-based primarily examine collaborative processes without incorporating CT-informed strategies (Li, 2023; Jeong, 2016). This reveals a significant research gap, as the structured cognitive scaffolding offered by CT may complement the collaborative dynamics of writing to enhance both writing outcomes and learner engagement.

Embedding CT into CW could allow students to approach writing tasks more systematically, dividing writing stages into subtasks (decomposition), focusing on main ideas (abstraction), recognising recurring issues (pattern recognition) and employing structured revision routines (algorithmic thinking). Table 1 illustrates how these CT principles align with different stages of the collaborative writing process in EFL instruction.

**Table 1** Conceptual model of CT integration into the web-based collaborative writing process

| Writing Process Stage | CT Concept Applied   | Description                                                                                             |
|-----------------------|----------------------|---------------------------------------------------------------------------------------------------------|
| Planning              | Decomposition        | Breaking the writing task into subcomponents (e.g., introduction, body, conclusion, subtopics)          |
| Idea Development      | Abstraction          | Focusing on main arguments, removing irrelevant ideas, identifying key messages                         |
| Drafting              | Algorithmic Thinking | Following systematic steps for writing: brainstorm → outline → draft                                    |
| Peer Review           | Pattern Recognition  | Identifying recurring errors or weaknesses during peer feedback (e.g., word repetition, grammar issues) |
| Revision              | Algorithmic Thinking | Applying structured revision routines to improve clarity, coherence, and correctness                    |

Yet, there is little empirical evidence that examines how such integration unfolds in authentic classroom settings, particularly at the secondary school level. The present study seeks to address this gap by investigating how EFL teachers implement CT-informed CW activities and how students engage with these integrated instructional practices.

To address this gap, the present study is guided by the following aim and research questions:

**Research Aim**

To explore how Computational Thinking (CT) concepts can be integrated into web-based collaborative writing (CW) in English as a Foreign Language (EFL) instruction and how this integration enhances teaching strategies and learner engagement in digital writing environments.

**Research Questions**

1. How can CT concepts (decomposition, pattern recognition, abstraction, and algorithmic thinking) be applied to web-based collaborative writing in EFL instruction?
2. What are the perceived benefits of integrating CT concepts into EFL collaborative writing in terms of student learning outcomes (e.g., coherence, clarity, critical thinking, and collaboration)?

**The Study**

This qualitative case study explored how seven Turkish high school EFL teachers integrated CT into web-based CW instruction. Seven teachers participated in the study, including four females and three males, with a mean age of 33.1 years, ranging from

twenty-five to forty-one. Participants were selected using purposive sampling based on their expressed interest in innovative pedagogical practices and voluntary participation in professional development (Creswell & Poth, 2018). All participants were employed at private high schools operating at ISCED Level 3, corresponding to upper secondary education (UNESCO Institute for Statistics, 2012), and were located in Istanbul and Izmir, Türkiye. The teachers had between five and fifteen years of professional experience, with a mean of 9.4 years.

## Research Context

The study was situated within a broader capacity-building initiative aimed at enhancing digital pedagogy and promoting 21st-century skills in Turkish secondary education. The participating teachers voluntarily enrolled in a professional development initiative designed to explore CT integration into subject-specific instruction. The focus on CW aligned with national priorities encouraging student-centred, technology-supported learning environments, particularly in light of post-pandemic educational adjustments.

## Workshop Design

The study commenced with a ninety-minute online interactive workshop that introduced participants to foundational CT concepts, including *decomposition*, *pattern recognition*, *abstraction*, and *algorithmic thinking*. The workshop also demonstrated how these concepts could be applied in the context of web-based CW. Teachers engaged in practical tasks such as breaking down an essay question into subcomponents, identifying linguistic patterns within texts, and co-writing a short article using a cloud-based platform (Google Docs). These activities enabled teachers to experience CT from a learner's perspective and reflect on its pedagogical relevance in EFL writing instruction.

## Implementation Phase

Following the workshop, each teacher integrated CT-informed CW activities into their classroom practice over the course of three to four sessions. These classroom activities encouraged students to apply CT principles by decomposing writing tasks into smaller segments, recognising stylistic or structural patterns, abstracting key arguments for clarity, and designing structured peer-review routines. The intention was to support the development of students' critical thinking, writing fluency, and digital collaboration skills.

## Ethical Considerations

The study adhered to institutional and international ethical standards for educational research. Prior to participation, all teachers were fully informed about the study's objectives, procedures, and their right to withdraw at any time without consequence.

Written informed consent was obtained from each participant. To ensure confidentiality, all data were anonymised and identifying information was removed during transcription. Pseudonyms were used in all reporting. Participation was entirely voluntary, and all reflective material was treated as confidential and used exclusively for research purposes.

### Data Collection

Two primary data sources were used to explore the teachers' experiences:

- **Focus Group Interview:** A semi-structured online focus group discussion was conducted in Turkish and lasted approximately two hours. This allowed participants to express their ideas and experiences more freely. The discussion was recorded, transcribed verbatim, and subsequently translated into English. The focus group explored teachers' understanding of CT, their reflections on classroom implementation, perceived challenges and benefits, and their comfort with using web-based collaborative tools.
- **Reflective Journals:** Each teacher maintained a reflective journal throughout the implementation phase and for one week after the workshop. These journals captured daily reflections, insights into student reactions and engagement, notes on classroom practices, and evolving attitudes towards the integration of CT in EFL writing. Several participants also included informal feedback from students who engaged with the CT-based tasks.

### Data Analysis

All qualitative data, including focus group interview transcript and journal entries, were analysed using thematic analysis as outlined by Braun and Clarke (2006). The researchers familiarised themselves with the data through repeated readings and employed an inductive coding approach, generating codes directly from the content rather than using a pre-existing framework. Coding was conducted independently by both researchers and then compared to ensure consistency. Codes were refined through discussion and organised into broader themes that captured commonalities across participants' experiences.

To enhance the trustworthiness of the findings, a process of member checking was undertaken. A summary of the emergent themes was shared with participants, who confirmed that the analysis accurately reflected their perspectives. All names reported in the findings were replaced with pseudonyms to protect participants' identities.

The final coding scheme consisted of three overarching themes, each encompassing several subthemes that emerged inductively from the data. These themes represent shared patterns across participants' experiences of integrating CT into collaborative EFL writing. The coding structure was developed through iterative comparison and discussion, ensuring that each subtheme was conceptually distinct while contributing to the broader thematic category. A summary of the thematic structure is provided in Table 2.

**Table 2** Emergent Themes and Subthemes from the Integration of Computational Thinking into Web-Based Collaborative Writing

| Theme                                                  | Subtheme                              | Description                                                                                                                                                      |
|--------------------------------------------------------|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Enhanced Coherence and Organisation</b>             | Decomposition as planning strategy    | Students divided writing tasks into logical components (e.g., introduction, body, conclusion), which supported structural clarity and task distribution.         |
|                                                        | Algorithmic thinking in sequencing    | Teachers guided students to follow a step-by-step process (e.g., brainstorm → draft → revise), which helped maintain focus and coherence in group writing.       |
| <b>Clarity of Expression through Critical Thinking</b> | Abstraction for idea refinement       | Students learned to identify main ideas and eliminate irrelevant content, resulting in more concise and purpose-driven writing.                                  |
|                                                        | Pattern recognition in peer review    | Collaborative editing practices involved identifying recurring issues (e.g., word repetition, grammar errors), leading to more accurate and varied language use. |
| <b>Increased Student Engagement and Motivation</b>     | Engagement through problem-solving    | Writing tasks were perceived as intellectually stimulating; students approached them like solving a puzzle, which increased active participation.                |
|                                                        | Digital tools enhancing collaboration | Tools such as Google Docs facilitated real-time interaction and accountability, which heightened motivation and involvement among students.                      |
|                                                        | Initial implementation challenges     | Some students experienced confusion when introduced to CT concepts, requiring scaffolding and instructional support from teachers.                               |

## Findings

Thematic analysis (Braun & Clarke, 2006) of the focus group interview transcript and reflective journals revealed three interrelated themes that illustrate how the integration of CT principles influenced CW practices in EFL classrooms. These themes are: (1) Enhanced Coherence and Organisation, (2) Clarity of Expression through Critical Thinking, and (3) Increased Student Engagement and Motivation. Each theme is supported by teacher narratives that offer insight into pedagogical processes, learner behaviour, and classroom dynamics.

## Enhanced Coherence and Organisation

The first theme concerns the impact of CT strategies on the structure and organisation of student writing. All participating teachers observed that the use of *decomposition* and *algorithmic thinking* contributed significantly to the structural quality of students’

texts. By breaking writing tasks into manageable components and applying a sequential writing process, students produced more logically organised compositions. As Teacher 3 explained in the focus group discussion: *“We divided the essay into introduction, body, conclusion, and even split the body among three subtopics. This made the final essay much more coherent, because each part was well-developed and connected.”* Reflective journals reinforced this perspective, particularly regarding the benefits of stepwise planning: *“I noticed that when my students followed a clear sequence – brainstorm, outline, draft, peer review, revise – their writing stayed on track. The algorithmic approach to writing kept everyone focused on their part, then we merged the parts smoothly.”* (Teacher 4) Teachers attributed these improvements in coherence to the scaffolding provided by CT strategies, which facilitated clearer task distribution and reduced redundancy across group members’ contributions.

### Clarity of Expression through Critical Thinking

The second theme highlights how CT principles supported greater clarity and critical engagement in student writing. Teachers reported that *abstraction* and *pattern recognition* helped students refine their ideas and language. *Abstraction* was particularly useful in encouraging students to identify key messages and remove extraneous content. Teacher 6 reflected on this shift in focus: *“Encouraging my students to identify the main idea of each paragraph made their writing more concise and clear. They started removing sentences that didn’t support the main point.”* *Pattern recognition* also emerged as a valuable tool during peer revision: *“After the group identified a pattern – for example, overusing the same transition word – they made edits to vary their language. It was a great exercise in noticing and improving their language use.”* (Teacher 7) These reflections suggest that the CT-informed writing process enhanced students’ ability to evaluate, revise, and improve their work with greater precision. Teachers noted an increase in students’ metacognitive awareness and their willingness to approach writing as an iterative, reflective task.

### Increased Student Engagement and Motivation

The final theme centres on the affective dimension of the writing process, particularly students’ motivation and participation. Teachers consistently reported high levels of engagement during CT-enhanced CW activities. The combination of problem-solving, group dynamics, and digital tools appeared to transform writing into an active and collaborative endeavour. As Teacher 2 noted: *“I have never seen my students so involved in a writing exercise. They were excitedly debating the best way to structure our essay, almost like they were solving a mystery together.”* (Teacher 2) Digital tools such as Google Docs also played a role in maintaining interest: *“Using Google Docs with these strategies turned writing into an interactive game. Each student had a role, and they loved it – even my typically quiet students were contributing actively.”* (Teacher 4)

While the overall response was positive, some teachers acknowledged initial implementation challenges. A few students struggled with unfamiliar CT terminology or required extra support in the early stages of task planning: *“Some students didn’t*

*understand at first what decomposition meant. I had to give examples, like planning a recipe step by step, to help them get it.*" (Teacher 1) Despite these early obstacles, the integration of CT concepts was widely seen as a catalyst for increased learner autonomy, confidence, and collaborative involvement.

Taken together, the themes suggest that CT principles enhanced not only the cognitive and structural dimensions of students' writing but also their emotional and social engagement with the learning process. Teachers reported that CT provided a practical, replicable framework for planning, evaluating, and refining writing tasks in group settings. Although some initial challenges were noted, the overall integration of CT into CW pedagogy was experienced as highly beneficial by both students and teachers.

## Discussion

This study explored how the integration of CT strategies into collaborative EFL writing influenced classroom practice. The research results reveal crucial understanding regarding both elements.

The teachers from this study used *decomposition* and *pattern recognition* along with *abstraction* and *algorithmic thinking* to implement CT concepts in their classroom writing instruction. The writing process involved *decomposition*, enabling students to divide tasks into introduction and body and conclusion sections while *algorithmic thinking* directed them to follow systematic steps from brainstorming to drafting to peer review and revision. The CT strategies provided a step-by-step method that enabled students to maintain both coherence and organisation during CW activities. Through *abstraction* students concentrated on essential ideas in their writing to discard unimportant details which enhanced both clarity and precision. Peer feedback processes received assistance from *pattern recognition* because students worked together to detect repeating problems with vocabulary repetition and structural errors which they applied specific revision methods to. The research results confirm previous studies which show CT enhances structured thinking as well as writing organisation according to Wu et al. (2024) and Yu et al. (2024).

The educational benefits of combining CT with EFL collaborative writing practices became apparent to teachers through multiple observed advantages. The teaching approach generated better writing outputs together with enhanced critical thinking abilities and stronger collaborative behaviours from students. The writing process revealed enhanced metacognitive skills in students because they started analysing their writing decisions. The problem-solving collaborative nature of CT tasks increased student engagement along with motivation levels. Students developed a dynamic puzzle-like perspective on writing which maintained their interest throughout the process. The findings align with previous research which demonstrated that web-based CW enhances learner autonomy while boosting active engagement (Li, 2023; Jeong, 2016). The implementation of CT required teachers to provide students with explicit modelling along with scaffolding support because students needed time to learn CT concepts during the initial

implementation phases. The successful implementation of CT in EFL writing instruction requires a phased introduction with teacher assistance according to these findings.

Despite these positive outcomes, several challenges were identified. Some students initially struggled to understand CT concepts, requiring clear examples and gradual instruction. Teachers also reported time limitations and curriculum pressures, highlighting the need for institutional support and flexible planning. These constraints suggest that effective integration of CT requires not only pedagogical adaptation but also strategic planning at the institutional level.

Importantly, the experience also supported teacher development. Participants reported an increased awareness of how to design structured, collaborative, and digitally mediated writing activities. This indicates that CT has the potential to promote reflective teaching practices alongside student learning.

## Conclusion

The research adds new insights to the developing body of knowledge concerning CT integration within EFL classroom instruction, specifically in web-based CW tasks. The research findings, based on the experiences of Turkish secondary school teachers, show that CT strengthens both cognitive writing processes and collaborative activities. Through *decomposition* and *algorithmic thinking*, students learn to structure their complex writing assignments, while *abstraction* and *pattern recognition* enhance their ability to produce clear and coherent texts. The interactive problem-solving nature of computational thinking fosters greater student engagement, self-directed learning, and increased confidence.

Educators who wish to implement CT in web-based CW should consider several practical recommendations. Teachers should introduce *decomposition* through explicit instruction during the planning process by helping students divide writing tasks into distinct, manageable components. The application of *algorithmic thinking* involves guiding students through step-by-step writing cycles that begin with drafting, proceed to reviewing, and conclude with revising. Teachers should incorporate abstraction activities to help students identify core ideas while eliminating superfluous material, and employ pattern recognition tasks within peer-review sessions to sharpen students' language awareness. It is essential that teachers provide continuous scaffolding and practical examples to introduce CT concepts gradually.

While this research yields important findings, additional studies are needed to investigate computational thinking-based teaching methods through extended classroom interventions and experimental designs conducted over multiple academic years. Future research should examine how CT supports language learners in developing reading comprehension, speaking and listening skills, and how emerging technologies, such as AI-based writing tools, may facilitate CT integration.

The integration of CT into web-based CW represents an effective approach to develop students' language skills and digital competence in EFL classrooms. Educational

institutions should adopt interdisciplinary approaches that combine language learning with CT in order to equip students with the skills necessary to navigate increasingly complex, technology-driven futures that will emerge from ongoing digital and societal transformations.

## REFERENCES

- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Černochová, M., & Selcuk, H. (2022). Primary education student teachers' perceptions of computational thinking through Bebras tasks. In D. Passey, D. Leahy, L. Williams, J. Holvikivi, & M. Ruohonen (Eds.), *Digital transformation of education and learning: Past, present and future. OCCE 2021. IFIP Advances in Information and Communication Technology* (Vol. 642, pp. 15–27). Springer, Cham. [https://doi.org/10.1007/978-3-030-97986-7\\_2](https://doi.org/10.1007/978-3-030-97986-7_2)
- Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE Publications.
- Daniela, L., Visvizi, A., Gutiérrez-Braojos, C., & Lytras, M. D. (2018). Sustainable higher education and technology-enhanced learning (TEL). *Sustainability*, 10(11), 3883. <https://doi.org/10.3390/su10113883>
- Gu, P., Wu, J., Cheng, Z., Zhang, W., & Zhao, Y. (2025). Scaffolding self-regulation in project-based programming learning through online collaborative diaries to promote computational thinking. *Education and Information Technologies*. Advance online publication. <https://doi.org/10.1007/s10639-025-13367-1>
- Jeong, K.-O. (2016). A study on the integration of Google Docs as a web-based collaborative learning platform in EFL writing instruction. *Indian Journal of Science and Technology*, 9(39), 1–7. <https://doi.org/10.17485/ijst/2016/v9i39/103239>
- Li, Y. (2023). The effect of online collaborative writing instruction on enhancing writing performance, writing motivation, and writing self-efficacy of Chinese EFL learners. *Frontiers in Psychology*, 14, Article 1165221. <https://doi.org/10.3389/fpsyg.2023.1165221>
- Pardede, P. (2024). Collaborative writing in EFL settings. *Journal of English Teaching*, 10(1), 92–109. <https://doi.org/10.33541/jet.v10i1.5631>
- Peng, H., Murti, A. T., Silitonga, L. M., & Wu, T. (2023). Effects of the fundamental concepts of computational thinking on students' anxiety and motivation toward K-12 English writing. *Sustainability*, 15(7), 5855. <https://doi.org/10.3390/su15075855>
- Selcuk, H., & Daniela, L. (2023). The use of online dictionaries during web-based collaborative writing among EFL learners. In L. Daniela (Ed.), *Proceedings of ATEE Spring Conference Innovations, Technologies and Research in Education* (pp. 505–515). University of Latvia. <https://doi.org/10.22364/atee.2022>
- Selcuk, H., Jones, J., & Vonkova, H. (2019). The use of Google Translate as an ICT tool in web-based collaborative writing: Self-reported accounts of EFL learners. In H. Kratochvilova & R. Kratochvil (Eds.), *Proceedings of IAC 2019 in Vienna* (pp. 74–80). Czech Institute of Academic Education.
- Storch, N. (2019). Collaborative writing. *Language Teaching*, 52(1), 40–59. <https://doi.org/10.1017/S0261444818000320>
- Tang, Y., & Ma, X. (2024). Relieving negative Chinese transfer in EFL syntactic writing through negative feedback based on computational thinking. *Thinking Skills and Creativity*, 53, Article 101624. <https://doi.org/10.1016/j.tsc.2024.101624>
- UNESCO. (2021). *Guidance for generative AI in education and research*. United Nations Educational, Scientific and Cultural Organization. <https://unesdoc.unesco.org/ark:/48223/pf0000386693>

- UNESCO Institute for Statistics. (2012). *International standard classification of education: ISCED2011*. UNESCO. <https://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf>
- Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, 49(3), 33–35. <https://doi.org/10.1145/1118178.1118215>
- Wu, T.-T., Silitonga, L. M., & Murti, A. T. (2024). Enhancing English writing and higher-order thinking skills through computational thinking. *Computers & Education*, 213, 105012. <https://doi.org/10.1016/j.compedu.2024.105012>
- Yu, X., Soto-Varela, R., & Gutiérrez-García, M. Á. (2024). How to learn and teach a foreign language through computational thinking: Suggestions based on a systematic review. *Thinking Skills and Creativity*, 52, Article 101517.
- Zhang, M., & Chen, W. (2022). Assessing collaborative writing in the digital age: An exploratory study. *Journal of Second Language Writing*, 57, 100868. <https://doi.org/10.1016/j.jslw.2022.100868>