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Improving ESL Writing Performance through Computational Thinking in Primary School: A Pilot Study

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ABSTRACT - This study examined the integration of Computational Thinking (CT) principles into English as a Second Language (ESL) writing instruction to enhance primary school pupils' writing performance. CT principles, including abstraction, decomposition, pattern recognition, generalisation, and evaluation, were embedded in writing lessons to support content development, organisation, and language use. A quasi-experimental design was employed involving 55 Year 4 pupils from a suburban primary school, divided into an experimental group (n = 27) and a control group (n = 28). The intervention was conducted over eight weeks, during which the experimental group received CT-integrated writing instruction, while the control group followed the standard Year 4 writing curriculum. The findings showed that the experimental group achieved significantly higher post-test writing performance than the control group ($p < .001$). The most substantial improvements were observed in content development and organisation, whereas improvements in language use were comparatively modest. Overall, the results indicate that integrating CT into ESL writing instruction is an effective pedagogical approach for improving primary pupils' writing performance.

INTRODUCTION

Mastery of writing is a crucial skill that supports both academic success and professional advancement. However, for English as a Second Language (ESL) learners, developing strong writing skills can be particularly challenging as they navigate the linguistic and structural complexities of writing in a foreign language. In recent years, computational thinking *(CT)* has gained recognition as an effective method for enhancing problem-solving and critical thinking skills across various disciplines (Lye & Koh, 2014; Peng et al., 2023; Wing, 2006). This study examines how integrating CT concepts into ESL writing instruction can enhance students' writing performance. Integrating CT into writing lessons has the potential to equip ESL learners with structured problem-solving strategies that support writing proficiency. Research has shown that CT contributes to computational literacy and positively influences writing outcomes (Sabitzer et al., 2018; Wu et al., 2024). Nevertheless, there is limited empirical research examining the impact of computational thinking on ESL writing performance among primary school pupils in the Malaysian context. In response to ongoing challenges in ESL writing development, this study aims to examine the effectiveness of integrating computational thinking concepts into ESL writing instruction for Year 4 pupils. This study seeks to bridge this gap by contributing to the expanding body of research on innovative instructional approaches for ESL writing. Additionally, it provides practical insights to inform curriculum design and enhance classroom implementation.

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RESEARCH BACKGROUND

The integration of computational thinking (CT) into educational settings has attracted considerable interest in recent years due to its potential to enhance problem-solving and critical thinking abilities. CT encompasses cognitive strategies commonly associated with computer science, including decomposition, pattern recognition, abstraction, and algorithmic thinking (Rottenhofer, Leitner, Kuka, et al., 2022; Wing, 2006). Although CT was initially developed within computer science education, increasing attention has been given to its applicability across other disciplines, particularly in language learning and writing instruction (Lye & Koh, 2014; Sabitzer et al., 2018; Wolz et al., 2011; Yeni et al., 2022).

Previous research indicates that CT fosters computational literacies such as problem formulation, data organisation and analysis, data representation through models, and solution automation (Csizmadia et al., 2015; Hsu et al., 2018; Rottenhofer, Leitner, Emara, et al., 2022). These competencies closely align with the cognitive demands of writing, which require learners to organise ideas, structure arguments logically, and communicate information clearly. When CT is integrated into writing instruction, learners are encouraged to adopt a more systematic and analytical approach to planning, drafting, and revising their written work (Peng et al., 2023; Wu et al., 2024).

Empirical studies have shown that CT-based writing instruction can enhance ESL learners' writing performance by supporting both writing proficiency and higher-order thinking skills. Specifically, integrating CT into writing lessons helps learners organise ideas more effectively, analyse texts critically, and develop structured arguments, which are key components of effective writing (Peng et al., 2023; Wu et al., 2024). In primary school contexts, CT-oriented writing tasks also promote problem-solving during the writing process, enabling pupils to identify weaknesses in their writing and make meaningful revisions.

Beyond cognitive benefits, research has also highlighted the affective advantages of CT integration in writing instruction. CT-based approaches have been associated with reduced writing anxiety and increased learner motivation, as structured problem-solving strategies make writing tasks more manageable and less intimidating for learners (Peng et al., 2023). Collectively, these findings suggest that CT serves as a promising pedagogical approach that not only strengthens ESL writing skills but also fosters critical thinking, creativity, and learner confidence.

Although the findings are positive, further empirical research is needed to deepen understanding on how CT can be effectively integrated into ESL writing instruction, particularly at the primary school level. Addressing this need, the present study seeks to examine the effectiveness of integrating CT concepts into ESL writing instruction in improving writing performance among primary school learners, with implications for the development of innovative and cognitively supportive writing curricula.

RESEARCH METHODOLOGY

This study employed a quasi-experimental design with pre-test and post-test measures to examine the effects of Computational Thinking (CT) on ESL writing performance (see Figure 1). The participants comprised 55 Year 4 pupils (aged 10) from a suburban primary school, assigned into two intact groups: an experimental group (n = 27) that received CT-integrated writing instruction using a structured module, and a control group (n = 28) that followed the standard ESL writing curriculum. To minimise instructional variability, the same teacher conducted lessons for both groups. Participant selection was based on ESL background and parental consent, with efforts made to ensure comparability in terms of age, proficiency level, and socioeconomic status.

The intervention was implemented over eight weeks and operationalised through unplugged, CT-based writing activities embedded within regular ESL lessons (see Figure 2). Core CT elements (decomposition, abstraction, pattern recognition, and algorithmic thinking) were systematically integrated into writing tasks. For example, pupils applied decomposition by breaking writing tasks into manageable components such as idea generation, content organisation, and paragraph development. Abstraction was used to identify and summarise key ideas from visual prompts or short texts using outlines or mind maps, while pattern recognition involved analysing model texts to identify recurring language structures and organisational features. Algorithmic thinking was reinforced through step-by-

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step writing procedures that guided pupils from planning and drafting to revising and editing. Both groups completed a diagnostic test and a pre-test before the intervention, followed by a post-test at the end of the instructional period.

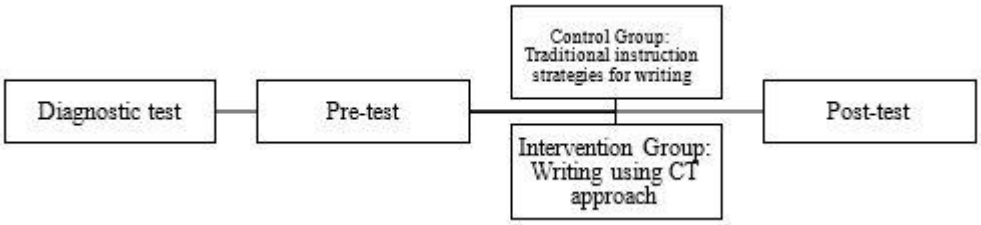

Figure 1. Study Design

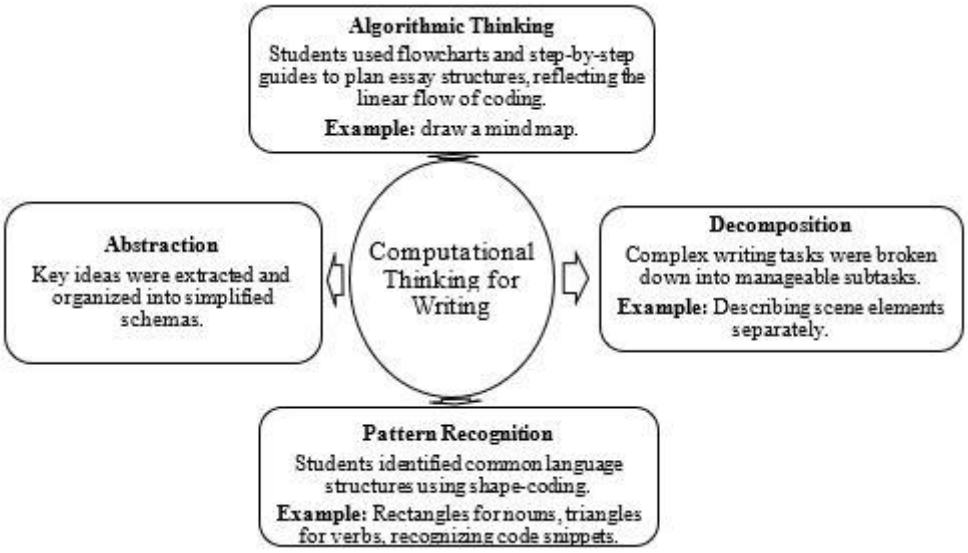

Figure 2. CT-based Task for the Module

The module was validated by experts in CT and ESL instruction and aligned with Common European Framework of Reference (CEFR) and Standard Curriculum Document (DSKP) standards. Writing tasks were adapted from the Final Academic Session (UASA) test format, and assessments were scored using a rubric developed by the Malaysia Examinations Board. The rubric measured key writing dimensions such as organization, content development and language use. Instruments were piloted and refined, with inter-rater reliability ensured. Data were analysed using independent samples t-tests and multivariate analysis of variance (MANOVA), followed by univariate analyses. Effect sizes were calculated using Cohen's d and eta squared (η^2) to compare group performance over time. Cohen's d was also calculated to determine effect sizes, using the benchmarks of small (d = 0.2), medium (d = 0.5), and large (d = 0.8). Figure 3 presents a summary of the experimental design employed in this study.

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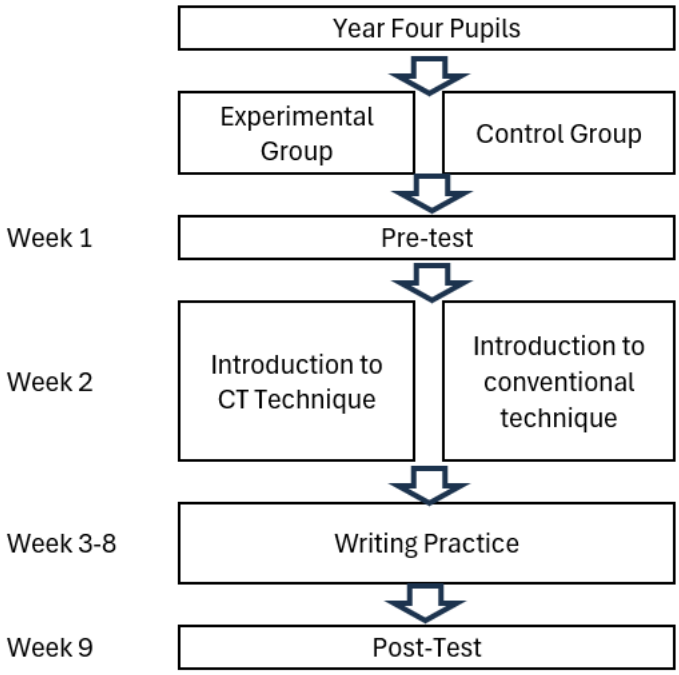

Figure 3. The Experimental Design

FINDINGS

This study examined the impact of integrating Computational Thinking (CT) principles into ESL writing instruction among Year 4 pupils. Independent samples t-test results revealed that pupils in the experimental group achieved significantly higher post-test writing scores (M = 4.07) compared to those in the control group (M = 2.41), $t(53) = 3.81$, $p < .001$, indicating a large effect size (Cohen's $d = 0.97$). This finding suggests that CT-integrated writing instruction was more effective than traditional writing instruction in enhancing overall writing performance.

A multivariate analysis of variance (MANOVA) was conducted to examine the effects of CT integration on specific writing dimensions, namely language use, organisation, and content development. The results showed a statistically significant multivariate effect of CT instruction, Wilks' $\Lambda = .71$, $F(3, 51) = 6.84$, $p < .001$, $\eta^2 = .29$. Follow-up univariate analyses indicated significant improvements in organisation, $F(1, 53) = 11.48$, $p = .001$, $\eta^2 = .22$, and content development, $F(1, 53) = 9.47$, $p = .003$, $\eta^2 = .15$. However, no statistically significant improvement was found in language use, $F(1, 53) = 2.14$, $p = .149$, $\eta^2 = .04$. As shown in Table 1, CT-integrated instruction had a significant impact on overall writing performance, organisation, and content development, while improvements in language use were not statistically significant.

Overall, the findings demonstrate that CT-based writing instruction effectively supports pupils' ability to organise ideas and develop content, while its impact on language accuracy remains limited. These results align with previous studies highlighting the role of CT in enhancing planning and structural aspects of writing rather than surface-level language features.

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Table 1. Comparison of Pre-Test and Post-Test Writing Performance by Writing Aspect

Writing Aspect	Statistical Test	F-statistic	*p*-value	Effect Size	Significant Impact
Overall Writing Score	Independent t-test	t(53) = 3.81	< .001	d = 0.97	Yes
Language Use	Follow-up univariate analysis (MANOVA)	F(1,53) = 2.91	.094	η^2 = .05	No
Organization	Follow-up univariate analysis (MANOVA)	F(1,53) = 15.62	< .001	η^2 = .23	Yes
Content Development	Follow-up univariate analysis (MANOVA)	F(1,53) = 9.47	.003	η^2 = .15	Yes

DISCUSSION

The study's findings provide preliminary empirical indications that integrating Computational Thinking (CT) concepts into ESL writing instruction may be beneficial for primary school pupils. However, these results should be interpreted with caution, as they are shaped by the specific instructional context and methodological constraints of the study, including the sample characteristics and research design. The significant enhancements in overall writing proficiency observed in the intervention group are congruent with prior research demonstrating CT's potential to augment problem-solving and critical-thinking capabilities (Wu et al., 2024). Notably, the positive impact of CT-integrated instruction was particularly prominent in organization and content development, implying that the utilized CT strategies (e.g., decomposition, pattern recognition, abstraction) facilitated more methodical and coherent writing processes among ESL pupils. These findings echo those of Peng et al., (2023) and Parsazadeh et al., (2021), who documented the corresponding benefits of CT interventions on the organizational facets of writing.

However, the limited improvement in language use among the intervention group underscores the continuing challenges encountered by ESL pupils in improving proficient language skills. While CT strategies can assist in the higher-order cognitive processes involved in writing, dedicated language instruction and practice remain necessary for enriching vocabulary, grammar, and overall language mastery (Rottenhofer, Leitner, Emara, et al., 2022; Zaman et al., 2019). Equipping pupils with problem-solving strategies and analytical approaches to writing tasks appeared to foster enduring writing competencies that extended beyond the immediate intervention period. This finding aligns with the theoretical foundations of CT, emphasizing the development of transferable problem-solving skills applicable across diverse contexts (Cabo & Lansiquot, 2016; Zaharin et al., 2018).

CONCLUSION

This research adds to the growing body of knowledge regarding the potential of CT to enhance writing proficiency, especially among ESL learners. The findings demonstrate that incorporating CT concepts and strategies into writing instruction leads to significant improvements in overall writing performance, as well as in specific areas such as organization and content development for primary school students. These results highlight the potential of CT as an effective pedagogical method for developing strong writing abilities in ESL students. The implications of this research are far-reaching, providing empirical evidence for integrating CT into language learning curricula and teaching practices. Educators can enhance the development of critical writing competencies necessary for academic and professional achievement by equipping ESL students with problem-solving techniques and analytical skills for writing tasks. Moreover, this study contributes to the broader conversation about the integration of CT across diverse fields, demonstrating its relevance and potential advantages beyond traditional computer

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science and STEM education contexts (Rottenhofer et al., 2021; Sharin Rawhiya Jacob, Miranda C. Parker, 2022; Xinlei Li, Guoyuan Sang, 2024). While the findings are encouraging, it is important to recognize the study's limitations and the need for further investigation.

Future research could explore the potential benefits of combining CT-integrated instruction with focused language support to address the ongoing challenges in language use faced by ESL learners. Additionally, longitudinal studies examining the long-term effects of CT-integrated writing instruction across different educational levels and ESL contexts would provide valuable insights.

In conclusion, this study offers compelling evidence that integrating CT concepts into ESL writing instruction can significantly enhance students' writing proficiency. Through structured and analytical approaches, CT-based instruction empowers ESL learners with the skills necessary to develop clear, organized, and effective writing. These enduring competencies not only strengthen their academic performance but also prepare them for future professional success, highlighting the transformative potential of CT in language education.

DECLARATION OF GENERATIVE AI

During the preparation of this work, the authors used ChatGPT (OpenAI) to enhance the clarity, language quality, and coherence of the writing. After using ChatGPT, the authors critically reviewed, edited, and revised the content as necessary and take full responsibility for the accuracy, originality, and integrity of the publication.

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