Assessing the Confluence of Computational Thinking and Design Thinking by Encompassing AI for EFL Communication Technology

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Abstract Although artificial intelligence (AI) is increasingly integrated into educational environments, there is still a lack of knowledge on how to appropriately combine design thinking (DT) and computational thinking (CT) to enhance English as a Foreign Language (EFL) communication skills teaching. This study aims to show how combining design thinking (DT) and computational thinking (CT) can work well together, addressing the lack of research on using both in AI-supported English as a Foreign Language (EFL) classroom. The contribution is in creating a confluence model that combines CT and DT components to enhance higher-order thinking, creativity, and problem-solving among EFL students. The study uses quantitative methods to examine how the CT-DT model is applied in different learning contexts, including artificial intelligence technology. Communication technology is AI technology that acts as a mediator for language use and cognitive engagement. Classroom observation instruments and thematic analysis indicated that students engaged more deeply in iterative reflection, ideation, and prototyping. The results highlight the possibility of adopting AI-driven activities to simultaneously enhance language skills and computational design literacy, empowering students as co-creators to enhance AI literacy. This inclusive approach improves communication skills and equips students to face future challenges in a technology-rich environment.

1 INTRODUCTION

In the cybergogy era, many language learning scenarios utilise artificial intelligence (AI) because of its reputation as a powerful tool for improving language mastery. However, language instructors may not always possess sufficient knowledge on how to effectively leverage AI in the classroom to support undergraduate students' learning processes [1]. Motivating students to learn English as a Foreign Language (EFL) remains a primary goal of language education, as effective EFL learning provides multiple benefits, including improved mastery of micro-skills (vocabulary and grammar) and macro-skills (reading, writing, listening, and speaking), transferable academic knowledge, and the development of essential soft skills.

Learning EFL is a time-consuming and demanding process, and students frequently encounter challenges related to learning attitudes, strategies, and confidence. One contributing factor is that traditional language classroom curricula have often prioritised control and accuracy over student expression and creativity [3]. As a result, creativity has typically been limited to linguistic competence or grammatical accuracy rather than originality of thought or meaningful content creation. Consequently, integrating computational thinking (CT) and design thinking (DT) approaches into EFL instruction presents both pedagogical challenges and opportunities.

Online approaches and strategies, such as learning languages through social media platforms (e.g., YouTube, Facebook, Instagram) and digital applications distributed through platforms such as the Google Play Store, have demonstrated potential in helping learners overcome barriers in EFL development [4]. At the same time, AI—defined as computer systems capable of imitating human intelligence in areas such as language interaction and

creative tasks [5]—can provide EFL learners with continuous, efficient learning support [6] and enhance contemporary teaching and learning practices. The ability of AI to generate comprehensible human-like text from data or simulate human language use is central to its application in language education [7]. In cybergogy-based learning environments, AI should not replace human agency but rather complement and collaborate with learners and teachers under human supervision, enhancing human capabilities rather than diminishing them [8].

AI-assisted language learning enables students to engage with EFL in interactive and personalised ways. The concept of machine-in-the-loop has been discussed as a human-centred approach to AI-supported learning, particularly in AI-mediated informal digital learning environments, where learners retain control over decision-making while interacting with intelligent systems [9]. In this model, humans maintain full autonomy over AI-generated content by revising, constructing, and modifying outputs according to their learning goals. When machine-in-the-loop approaches are applied to English language learning, computational thinking strategies and learner motivation may influence the effectiveness of human–AI collaboration [10]. Research indicates that AI can play an active role in such collaborative writing processes by increasing efficiency and supporting idea development.

This study proposes an instructional approach that integrates AI into EFL learning, beginning with micro-skills and gradually progressing to macro-skills. Undergraduate students participate in project-based learning activities by creating digital artefacts, such as dialogue-based projects, using their own vocabulary, sentence structures, ideas, and prototypes. These artefacts are supported and personalised by AI Tutor Lily, an intelligent natural language generation tool. The purpose of this paper is to describe EFL learning outcomes within a metaverse learning environment that integrates computational thinking and design thinking. It is argued that this integrated approach enables students to develop EFL competencies through the combined application of AI, CT, and DT activities.

2 CT AND DT MODELLING IN EFL COMMUNICATION TECHNOLOGY

Facilitating student learning in AI-supported environments can be achieved by designing classroom activities grounded in computational thinking. This process typically begins with presenting learners with a problem, followed by solution development through problem decomposition, pattern recognition, abstraction, algorithm design, and evaluation. Developing the ability to access and interpret publicly available information is also considered an important learning outcome.

A comprehensive understanding of the learning context is essential for generating viable solutions. Computational thinking is widely recognised as a fundamental skill for problem-solving, encompassing key concepts such as decomposition, pattern recognition, abstraction, algorithmic thinking, and evaluation [11]. These concepts involve breaking complex problems into manageable components, identifying recurring patterns, designing step-by-step solutions, abstracting transferable principles, and assessing solution effectiveness.

In many Indonesian higher education contexts, English courses rarely incorporate AI-based instructional methods, and students are often beginners in digital and creative language production. As a result, their creative processes may be constrained, and EFL learning requires considerable cognitive effort. While students may demonstrate motivation, they frequently exhibit limited planning skills and insufficient understanding of how to design creative digital artefacts using EFL. Even proficient EFL learners often struggle with lexical selection and grammatical accuracy during text composition. Consequently, learners typically begin EFL development at the micro-skill level before advancing to macro-skill proficiency.

Many students also experience difficulty organising and visualising ideas prior to engaging in macro-skill tasks. Grammatical errors and typographical mistakes are common among learners with limited experience in text organisation, structural coherence, and idea development. Viewing EFL instruction as a problem-solving process that emphasises idea organisation, advanced language competencies, and peer interaction has been suggested as an effective strategy for improving writing skills. Computational thinking principles have been developed to support such instructional approaches. Although CT has increasingly been recognised as a crucial skill for the modern workforce, research on its application beyond programming and computer science remains limited [12]. Nevertheless, existing studies indicate that CT can enhance language learning by providing structured methods for addressing writing challenges

in English [13]. By applying CT principles, students can improve writing mechanics through systematic analysis of sentence structures and linguistic patterns [13].

The primary goal of computational thinking in English language teaching is to support learners in developing language proficiency through structured, critical, and creative problem-solving processes [14]. In the context of globalisation, undergraduate students are expected not only to develop effective EFL communication skills but also to synthesise ideas and produce well-organised academic work. Decomposition techniques allow learners to simplify complex linguistic concepts, while microlearning strategies—such as vocabulary brainstorming and sentence construction—support gradual skill development [15]. Brainstorming activities further enable students to activate relevant prior knowledge related to specific topics.

Pattern recognition plays a crucial role in helping students identify grammatical and lexical regularities. Through this process, learners focus on verbs, predicates, and syntactic structures used in phrases and sentences. Research has shown that students who are trained to identify grammatical patterns can apply these patterns to construct concise and coherent sentences [13]. Abstraction, which involves generalising problem-solving strategies across different contexts, allows learners to apply grammatical rules for various parts of speech in English writing [16]. Although learners may invest significant time in decomposition, pattern recognition, and abstraction, they may still struggle with logical organisation. Algorithmic thinking addresses this challenge by guiding students to construct sentences and texts based on structured sequences of steps that can be transferred to similar language tasks [16].

Design thinking further encourages students to produce creative language artefacts. Although its application in EFL education remains underexplored, DT has demonstrated potential as an instructional approach for fostering 21st-century skills. The DT process begins with empathy, which involves understanding learners' needs and perspectives [17], [18]. In this study, empathy was developed through discussion forums that allowed undergraduate students to share their experiences and challenges. The ideation stage then encouraged the generation of diverse solutions, followed by evaluation and selection of the most feasible ideas. Through iterative prototyping, experimentation, and reflection, students refined their solutions collaboratively.

The prototyping phase required students to create functional language artefacts, which were subsequently tested and revised based on feedback. Students worked in groups to apply DT principles by brainstorming ideas, evaluating alternatives, selecting optimal solutions, and implementing them in practice [19]. While English was encouraged as the primary medium of communication, students occasionally engaged in code-switching to Indonesian when addressing complex concepts or resolving disagreements. Student creativity, linguistic competence, and critical thinking skills were assessed through original, multimodal tasks. The quality and relevance of these assessments indicated a strong understanding of the creative process, with divergent thinking playing a dominant role [18].

3 METHOD

This quantitative study was conducted in the 2023 academic year, when undergraduate students underwent EFL English learning with an AI-based curriculum. District data shows that 100% of undergraduate students identified as Indonesian, and they are English language learners who are eligible to get material by integrating AI with the characteristics of having a smartphone, being able to operate AI, having a quota, and having a good internet network. The design of this study used a pre-experimental design with one group.

The population of this study was 306 undergraduate students from the faculty of public health and the research sample was 51 first-semester undergraduate students with an age range of 17–18 years: 17 undergraduate students or 34%; 19-year-olds, 38 percent (19 students); 20-year-olds, 12 percent; and 22–27-year-olds, 14 percent. A questionnaire survey was given after participating in EFL English learning with AI-integrated CT and DT modeling. Individual surveys with undergraduate students regarding computational modelling and design thinking were administered via a Google form shared with them to answer the research questions for this study. 95.8% of the 51 study participants identified as female. All of these undergraduate students grew up as non-native English speakers.

The learning plans used during learning are listed in Table 1.

Data collection instruments were used to collect results, including demographic surveys, content rubrics, CT and DT surveys, final artefacts and products (uploaded to YouTube), and quantitative data obtained from questionnaire survey results. At

the end of the lecture series, students are asked to fill out a demographic survey asking about age, gender, grades, and personalized learning experiences with AI, CT, and DT.

As a final result, the EFL language performance of the project's digital artefacts was collected at the end of the lecture series. Physical copies of EFL training are sent via WhatsApp groups. Collecting content rubrics, CT and DT surveys, and digital artefacts allowed for a thorough quantitative assessment of this group. The in-depth perspectives and experiences gained from focus groups complement this. Because undergraduate students tend to feel more comfortable opening up and discussing their experiences working in groups to practice their English through AI, CT, and DT activities, Criteria for assessing structure, grammar, pronunciation/vocabulary, and organisation of English content are outlined in the content rubric.

Table 1: AI-integrated CT/DT EFL lesson plan.

Phase and Timing	Activities and CT/DT Elements
Learning objective	Undergraduate students utilise AI in the classroom to develop computational and design thinking skills and apply them to real-world scenarios in the context of EFL foreign language learning.
Materials used during the study	1) Smartphone or laptop with 5G internet access. 2) Artificial intelligence. 3) Google translates. 4) Mind-mister apps.
Opening (15 minutes) Engage phase.	At this stage, lecturers and undergraduate students discuss the importance of computational thinking skills and design thinking, along with examples, in solving EFL foreign language problems. Next, undergraduate students are asked to prepare and download the required learning applications, and then the lecturer provides a simulation of using the materials.
Main activities (60 minutes) Algorithm design (CT) and empathy (DT)	Exploring and explanation phase: 1) The lecturer explains the material. 2) The lecturer explores the CT and DT of undergraduate students. 3) The lecturer asks undergraduate students to form working groups and then asks them to activate and work with Tutor Lily step by step on algorithm design and empathy. 4) Lecturers guide students carefully.
Practical training (30 minutes)	1) Undergraduate students and their group friends begin to construct their knowledge by utilising AI to access vocabulary related to material, such as present tense and past tense. They are breaking into easier understanding (CT = decomposition). 2) Then undergraduate students are guided to emphasise the adaptive features of AI Tutor Lily to access vocabulary related to the material. 3) Lecturers encourage collaboration between AI and mind mapping (ideate design, DT). Construction stage of present tense characteristics using mind mapping for EFL problem solving and critical thinking in groups by creating grammatically correct sentences (define, DT, and abstraction, CT). 4) After classifying and identifying the characteristics of the present tense, undergraduate students are then asked to design sentences according to the material being taught. (Decomposition and pattern recognition, CT). 5) Then undergraduate students are asked to create dialogue according to the material (algorithmic design).
Explanation phase	1) Lecturers facilitate class discussions by activating undergraduate students' computational thinking and design thinking to overcome challenges during practical activities (abstraction, CT, and prototype, DT). 2) Lecturers direct undergraduate students to connect practical learning experiences with the real world in prototype form so that they understand the function of these tenses and provide appropriate solutions (pattern recognition, CT).
Project-based learning through DT (20 minutes)	1) Students present the prototype of the dialogue for communication action (DT). 2) This stage encourages student creativity and explores various solutions. 3) EFL foreign language practice is documented in video form and uploaded to a YouTube account. Video example[1].
Closing activity (10 minutes)	Reflection and Test: 1) The lecturer asks each group to provide feedback on the prototype presented (iterate and refine, DT). 2) Lecturers evaluate the learning process and give appreciation to student projects. 3) The lecturer closes the lesson by praying together.

[1] https://www.youtube.com/watch?v=MqY7PWvGLuo

There are four levels of difficulty for each question: emerging, developing, advanced, and practiced. At the beginning of each class, we give this rubric to students to use as a guide to what they should learn. At the end of the course, at the 14th meeting, students use this rubric to grade their own prototypes and those of other groups. Students were also given a CT and DT self-evaluation survey on a 5-point Likert scale to complete. Twenty items were divided into two groups, consisting of 10 items for CT and 10 items for DT. On a scale of 1 to 5, students evaluate themselves. Score 1: I'm still confused about what it is; score 2: I'm not sure I can do it; score 3: I know what it is, but I still haven't found the answer. Score 4: That's within my means; and score 5: I can do it and explain it.

The CT and DT survey data were analysed using IBM SPSS Statistics 26 by calculating the frequency of each item. To explore the data further, we used paired sample t-tests on total and individual items from the pre- and post-survey stages. Focusing on changes in students' attitudes towards EFL language learning as well as the use of AI, computing, and design, the test aims to detect statistically significant mean differences between before and after the survey. By standard statistical practice, a significance level of ≤0.05 was set first for this analysis.

4 FINDINGS AND DISCUSSION

According to the quantitative statistics described in Table 1 below, students' positive attitudes towards their EFL showed a statistically significant increase from the beginning to the end of engagement.

The statistical test results shown in Table 2 show that the pre-test scores from 49.7647 (with a standard deviation of 3.79783) increased significantly to 83.4706 (with a standard deviation of 7.00386) in the post-test scores. The results of this data, obtained from a sample of 51 participants, showed differences in scores before and after treatment. The measured variable data increased significantly from pretest to posttest, as demonstrated by the one-sample test findings, which showed a significant positive difference from a test score of 0, with a significant average difference and a narrow confidence interval.

The results of the research data on pre-test and post-test scores show very significant differences in scores Table 2. Likewise, the results of the survey, Table 3, which involved 51 participants, show that all respondents agree on how effective problem-solving strategies, logical reasoning, and AI integration are in language-related tasks. They felt confident and had positive attitudes towards various aspects of AI, such as algorithmic thinking, empathy, collaboration, and how much they enjoyed AI-assisted language learning Table 1.

Table 2: Students' positive attitudes towards their EFL.

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference
Pretest	93.577	50	.000	49.76471	48.6965
Posttest	85.110	50	.000	83.47059	81.5007

This research contributes to and provides knowledge to better understand how undergraduate students in public health study programmes use AI to reflect computational thinking and design thinking skills to achieve learning outcomes by communivation practice. We designed a lesson plan that describes CT and DT in AI-assisted learning activities to find out how they participate during the EFL language acquisition process. Our findings from observations and surveys show that students demonstrate four thinking and design thinking skills:

1) taking a holistic view of complex systems and then simplifying them;
2) recognising interdependencies in collaboration to produce creative ideas;
3) stratifying their thinking;
4) demonstrating the algorithm and prototype effectively.

Based on the data from observation and monitoring in the classroom Table 1, this research supports the growing body of evidence that shows students can participate in CT and DT, although with some difficulties in EFL, namely incorrect grammar and pronunciation. Students showed signs of exploring complex systems holistically when they described their computational models and DT during the learning process. Even though at the beginning of the meeting they still felt difficulties, they still spent time understanding the learning activities. In particular, students interpret vocabulary related to the material (e.g., present tense) by accessing Tutor Lily and simplifying it according to daily activities and surrounding phenomena. The ability to create grammatically correct sentences, which is the core ability of EFL language acquisition, supports their involvement in CT and DT thinking processes.

Table 3: DT and CT survey.

Statements	N	Min	Max	Mean	SD
1) I am comfortable solving problems systematically using step-by-step procedures.	51	3.00	5.00	4.5882	.66862
2) I often use logical reasoning to break down complex tasks into smaller, more manageable steps.	51	2.00	5.00	4.5098	.75822
3) I can identify patterns in information or language learning materials.	51	3.00	5.00	4.2549	.79607
4) I use pre-defined algorithms or strategies when facing language-related challenges with the help of AI.	51	3.00	5.00	4.1765	.84157
5) I apply abstraction by focusing on important details and ignoring unnecessary information.	51	3.00	5.00	4.4118	.75303
6) I am confident that I can recognise and fix errors or bugs when operating AI Story.	51	2.00	5.00	4.3529	.77003
7) I believe in applying decomposition to break down language tasks into simpler AI-based components.	51	2.00	5.00	4.3725	.84760
8) I use algorithmic thinking in language-related activities, such as composing short stories with AI Story.	51	2.00	5.00	4.1765	.86501
9) I feel comfortable recognising similarities between language learning concepts and real-world practice.	51	2.00	5.00	4.1961	.87223
10) I believe that by thinking algorithmically when faced with EFL language-based problem-solving tasks, they can be handled well.	51	2.00	5.00	4.2157	.92334
11) I empathise with the perspectives and needs of language learners or your audience when creating dialogue script content by integrating AI.	51	2.00	5.00	4.2157	.90142
12) I believe that with the help of AI, we can determine challenges or goals related to language before starting a project, starting with classifying vocabulary, determining the intrinsic and extrinsic elements of a short story and translating it into Indonesian.	51	2.00	5.00	4.4706	.75771
13) I often brainstorm and think of various possibilities for language-related assignments or assignments with my group mates and AI.	51	2.00	5.00	4.2549	.82081
14) I'm interested in prototyping or creating an initial draft of a short story before completing the project.	51	2.00	5.00	4.2941	.87850
15) I believe in receiving and integrating feedback with peer groups and AI.	51	2.00	5.00	4.2549	.86817
16) I often collaborate with colleagues or seek different perspectives when working on EFL-related projects.	51	2.00	5.00	4.1373	.98020
17) I consider the aesthetics and user experience of the AI.	51	2.00	5.00	4.2157	.87895
18) I iterated and refined the project based on feedback and evaluation with group mates.	51	2.00	5.00	4.1176	.93053
19) I redesign the work (AI) and adapt it to meet the needs or challenges of an evolving audience.	51	2.00	5.00	4.1569	.88029
20) I enjoy the activity of learning EFL with the help of AI and design thinking procedures.	51	2.00	5.00	4.1373	.95958

Students can participate in the analysis and interpretation of present tense, starting with classifying the correct vocabulary and its characteristics, which is usually difficult, but thanks to this ability, in the practice phase, students demonstrate understanding and skills in describing material with algorithmic design. For example, undergraduate students engineered their dialogue interactions with AI-Tutor Lily and designed their prototypes. This confirms what previous research has shown: that students can understand the big picture when it comes to AI [20].

Given the large body of literature on the difficulties of teaching and learning EFL, the finding that public health students can describe their English and interactions with AI is encouraging students to be able to programme interactions with AI using CT and DT models of abstraction, decomposition, and empathy to reflect their ideas. This may have helped them overcome these obstacles. Considering that even undergraduate students often find thinking in levels a difficult technique of systems thinking, these results are quite encouraging. The findings we suggest regarding students' successful integration of

CT and DT will help educators better understand how to cultivate these skills, especially for those learning English as a foreign language. As students move through exploring more complex CT and DT learning systems, this type of learning model can serve as a basis for their problem-solving.

Students' CT may benefit from the presence of a relevant scientific framework, which is another explanation in a familiar situation relating to real-world observations that has been shown to help students, especially younger ones, according to previous research [21]. Another possible reason is that students are able to think systematically and think design by utilising information from various sources, not limited to computational models alone. Utilisation of student weight data from tense character investigations is very important in assessing the accuracy of their computational models and DT in describing daily activities related to phenomena that can be analogous to tenses (or given material such as weather, telling time, direction, and others). Computational modelling in EFL language classes to encourage them to triangulate data from various sources. When given a familiar situation, students have no difficulty thinking about building their models, but when faced with something new, they have difficulty. For example, when asked to abstract the present tense in everyday life and related phenomena and predict the consequences of using the present tense to become present continuous and present perfect, we offer interaction with AI. The fact that students are at a developmental stage towards more sophisticated engagement with the practice of thinking in levels, which is a skill that develops over time and that technology integration is capable of making possible, may help to explain this finding.

AI integration with CT and DT activities shows promise as tools for engaging students in the practice of complex systems thinking and design thinking while creating learning experiences. Lastly, even though their English is far from ideal (native speaker accent) to put themselves in the position of an agent, EFL English learners convey their scientific concepts regarding the material through a combination of various modalities and sometimes imperfect English because it is still influenced by their mother tongue. For example, when a spelling error occurs that is similar to Indonesian, such as the word discuss (which can be seen in the YouTube link in Table 1, do not assume that EFL students must have achieved "full" English proficiency before they can participate in complex systems thinking practices; however, students will eventually be encouraged to use better expressions when they demonstrate prototypes. There needs to be more research on the pros and cons of teaching systems thinking to different types of students. However, this study suggests that computational thinking, design thinking, and design thinking with AI could be useful for creating modern EFL lessons that meet the needs of college students in the digital era.

Successful integration of AI, CT, and DT activities in a metaverse learning environment for the EFL classroom faces challenges such as technological infrastructors and ethical issues regarding data privacy and use. The limitation in generalizability to diverse educational settings and the short duration of pre-experimental designs. This study also recommends increasing the integration of AI, CT, and DT in EFL classrooms, including collaboration with IT infrastructure, implementing strategies for equitable access, providing proficiency training for students and instructors, establishing ethical guidelines, developing engagement strategies, considering longitudinal study designs, and advocating collaboration with educational stakeholders to inform decision-making and advance EFL teaching practices.

5 CONCLUSIONS

Based on the results of this research, it is clear that undergraduate students in higher education institutions studying EFL can practice CT and DT. Here, we draw attention to the most important contributions of this research. To begin with, the research results show that students' CT and DT can be significantly improved when EFL lessons integrate AI. The second important thing is that CT and DT are meaningful learning systems that undergraduate students can undertake and build upon throughout their studies, not just in these courses. Third, the results show that the integration of AI promotes CT and DT in EFL, which can pave the way for having self-confidence and a positive attitude when facing more and more classical language acquisition problems and complex learning systems in other fields. In conclusion, the results show that all students, even those who are still developing their language skills, can have access to CT and DT activities.

These results describe that the learning instructions of this research show students learn more effectively when they are asked to simulate different iterations through complex thinking methods. For our design-based studies, this may mean, for example, expanding the CT and DT challenges. Second, rather than focusing on a single unit of instruction,

researchers should track the growth of CT and DT over multiple units of time. As part of design-based research, we can track students' progress towards more systematic thinking throughout the year as they explore language phenomena from a variety of scientific fields in our curriculum aligned with the digital age. Third, more varied student groups and larger samples should be used to study EFL and develop CT and DT. Given this diversity of students, our AI-based research may lead to wider adoption by EFL learners from diverse backgrounds. The educational community must support all students in developing CT and DT by providing resources, as these skills are becoming increasingly important in today's complex and networked society in the era of the educational metaverse.

REFERENCES

[1] J. Crawford, C. Vallis, J. Yang, R. Fitzgerald, C. O'Dea, and M. Cowling, "Artificial intelligence is awesome, but good teaching should always come first," Journal of University Teaching & Learning Practice, vol. 20, no. 7, p. 01, 2023.

[2] Z. Akbari, "Current challenges in teaching/learning English for EFL learners: The case of junior high school and high school," Procedia-Social and Behavioral Sciences, vol. 199, pp. 394–401, 2015.

[3] A. McCallum, Creativity and Learning in Secondary English: Teaching for a Creative Classroom. London, UK: Routledge, 2012.

[4] S. Jin, "Tapping into social media: Transforming EFL learners' writing skills and alleviating anxiety through YouTube," Education and Information Technologies, pp. 1–22, 2023.

[5] K. Godel, "Innovative problem solving at the heart of artificial intelligence," in AIU Central Zone Vice Chancellors' Meet 2023–24, vol. 62, pp. 107–112, 2024.

[6] Y. A. Alshumaimeri and A. K. Alshememry, "The extent of AI applications in EFL learning and teaching," IEEE Transactions on Learning Technologies, 2023.

[7] H. Shafiee Rad, "Revolutionizing L2 speaking proficiency, willingness to communicate, and perceptions through artificial intelligence: A case of Speeko application," Innovation in Language Learning and Teaching, pp. 1–16, 2024.

[8] T. Y. Tai, "Comparing the effects of intelligent personal assistant–human and human–human interactions on EFL learners' willingness to communicate beyond the classroom," Computers & Education, vol. 210, p. 104965, 2024.

[9] G. L. Liu, R. Darvin, and C. Ma, "Exploring AI-mediated informal digital learning of English (AI-IDLE): A mixed-method investigation of Chinese EFL learners' AI adoption and experiences," Computer Assisted Language Learning, pp. 1–29, 2024.

[10] Muthmainnah, A. J. Obaid, A. Al Yakin, and M. Brayyich, "Enhancing computational thinking based on virtual robot of artificial intelligence modeling in the English language classroom," in Proc. Int. Conf. on Data Analytics & Management, Singapore: Springer Nature, pp. 1–11, Jun. 2023.

[11] A. Al Yakin, A. J. Obaid, Muthmainnah, A. H. Shnawa, and N. H. Haroon, "Unlocking the potential of mobile computing for infusing computational thinking using social cognitive approach in higher education institutes," in Proc. Int. Conf. on Data Analytics & Management, Singapore: Springer Nature, pp. 105–114, Jun. 2023.

[12] N. Parsazadeh, P. Y. Cheng, T. T. Wu, and Y. M. Huang, "Integrating computational thinking concept into digital storytelling to improve learners' motivation and performance," Journal of Educational Computing Research, vol. 59, no. 3, pp. 470–495, 2021.

[13] T. T. Wu, L. M. Silitonga, and A. T. Murti, "Enhancing English writing and higher-order thinking skills through computational thinking," Computers & Education, p. 105012, 2024.

[14] X. Wang, M. Cheng, and X. Li, "Teaching and learning computational thinking through game-based learning: A systematic review," Journal of Educational Computing Research, vol. 61, no. 7, pp. 1505–1536, 2023.

[15] V. Eisenlauer, "The EFL-YouTube remix: Empowering multimodal and computational literacies for EFL purposes," Journal of Visual Literacy, vol. 39, no. 3–4, pp. 149–166, 2020.

[16] C. Zhou and W. Zhang, "Computational thinking towards creative action: Developing a project-based instructional taxonomy in AI education," Education Sciences, vol. 14, no. 2, p. 134, 2024.

[17] M. Rajabova, "The importance of using design thinking methodology in teaching English," Innovative Development in Educational Activities, vol. 3, no. 1, pp. 304–314, 2024.

[18] M. Griffith and C. Lechuga-Jimenez, "Design thinking in higher education case studies: Disciplinary contrasts between cultural heritage and language and technology," Education Sciences, vol. 14, no. 1, p. 90, 2024.

[19] I. Pondelíková, "Design thinking for specific purposes: Comparative study of design thinking technique to enhance educational process for students of English and teachers of various academic fields," Journal of Teaching English for Specific and Academic Purposes, pp. 633–650, 2024.

[20] Y. Zhang, "A lesson study on a MOOC-based and AI-powered flipped teaching and assessment of EFL writing model: Teachers' and students' growth," International Journal for Lesson & Learning Studies, 2024.

[21] J. del Olmo-Muñoz, A. Bueno-Baquero, R. Cózar-Gutiérrez, and J. A. González-Calero, "Exploring gamification approaches for enhancing computational thinking in young learners," Education Sciences, vol. 13, no. 5, p. 487, 2023.