



El efecto de la robótica en la motivación y el pensamiento computacional en el aprendizaje del inglés

The Effect of Robotics on Motivation and Computational Thinking in English Learning

O Efeito da Robótica na Motivação e no Pensamento Computacional na Aprendizagem do Inglês

María Eugenia Basantes Jaramillo ^I

marubasantes@gmail.com

<https://orcid.org/0009-0004-6573-6534>

Amy del Carmen Analuisa Ortiz ^{II}

analuisaamy05@gmail.com

<https://orcid.org/0009-0004-7836-1727>

Gabriela Salomé Salgado Ortiz ^{III}

gabrielas.salgado@docentes.educacion.edu.ec

<https://orcid.org/0009-0005-0046-802X>

Piedad Rosario Guijarro Paguay ^{IV}

piaguijarrop@hotmail.com

<https://orcid.org/0000-0002-0887-7689>

Correspondencia: marubasantes@gmail.com

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- I. Licenciada en Ciencias de la Educación Profesora de Idiomas Ingles, Magíster en Gerencia de Proyectos Educativos y Sociales, Docente de Ingles de la Unidad Educativa "Fernando Daquilema", Ecuador.
- II. Licenciada en Pedagogía del Idioma Inglés, Docente de inglés - Instituto de idiomas English For Everyone (EFE), Ecuador.
- III. Ingeniera Mecánica, Master en Educación, Docente Técnica Colegio Técnico Carlos Cisneros, Riobamba, Ecuador.
- IV. Magister en Enseñanza de Inglés como Lengua Extranjera (C), Investigadora Independiente, Ecuador.

Resumen

Este estudio examina la influencia del aprendizaje basado en robótica sobre la motivación y el pensamiento computacional de los estudiantes en el contexto de la enseñanza del idioma inglés. La investigación responde al desafío persistente de involucrar a los aprendientes en procesos educativos significativos que integren la tecnología y promuevan simultáneamente el desarrollo cognitivo y lingüístico. A través de un diseño cuantitativo de tipo pretest-posttest complementado con observaciones cualitativas, participaron 86 estudiantes de educación secundaria distribuidos en grupos experimental y de control. La intervención consistió en talleres interdisciplinarios que integraron las áreas de inglés, Matemáticas y Sistemas Computacionales, en los cuales los estudiantes programaron robots utilizando comandos en inglés. Los análisis estadísticos evidenciaron mejoras significativas en la motivación ($t(84) = -22.10, p < .001, d = 2.41$) y en el pensamiento computacional del grupo experimental en comparación con el grupo de control. Las observaciones cualitativas revelaron, además, un mayor nivel de compromiso, uso auténtico del idioma y resolución colaborativa de problemas. Se concluye que la robótica no solo potencia la motivación y las habilidades cognitivas, sino que transforma el aprendizaje del inglés en una experiencia comunicativa funcional y creativa, sustentada en la colaboración interdisciplinaria.

Palabras Clave: aprendizaje basado en robótica; inglés como lengua extranjera; motivación; pensamiento computacional; educación interdisciplinaria.

Abstract

This study examines the influence of robotics-based learning on students' motivation and computational thinking in the context of English language education. It responds to the persistent challenge of engaging learners in meaningful, technology-integrated language instruction that fosters both cognitive and linguistic development. Using a quantitative pretest-posttest design complemented by qualitative observations, the study involved 86 secondary students divided into experimental and control groups. The intervention consisted of interdisciplinary workshops integrating English, Mathematics, and Computing Systems, where students programmed robots using English commands. Statistical analyses revealed significant improvements in motivation ($t(84) = -22.10, p < .001, d = 2.41$) and computational thinking in the experimental group compared to the control group. Qualitative notes further illustrated increased engagement, authentic language use, and collaborative problem-solving. These findings confirm that robotics not only enhances

learners' motivation and cognitive abilities but also transforms the use of English into a functional and creative communicative tool. The study concludes that robotics-based instruction, supported by interdisciplinary collaboration, offers an effective pathway to integrate linguistic, technological, and motivational dimensions in 21st-century education.

Keywords: robotics-based learning; English as a foreign language; motivation; computational thinking; interdisciplinary education.

Resumo

Este estudo examina a influência da aprendizagem baseada na robótica na motivação e no pensamento computacional dos alunos do ensino de inglês. A investigação aborda o desafio persistente de envolver os alunos em processos educativos significativos que integrem a tecnologia e, simultaneamente, promovam o desenvolvimento cognitivo e linguístico. Utilizando um desenho quantitativo pré-teste/pós-teste complementado por observações qualitativas, participaram 86 alunos do ensino secundário, divididos em grupos experimental e de controlo. A intervenção consistiu em workshops interdisciplinares que integraram o Inglês, a Matemática e os Sistemas de Computação, nos quais os alunos programaram robôs utilizando comandos em inglês. As análises estatísticas revelaram melhorias significativas na motivação ($t(84) = -22,10$, $p < 0,001$, $d = 2,41$) e no pensamento computacional no grupo experimental em comparação com o grupo de controlo. As observações qualitativas revelaram também um maior nível de envolvimento, uso autêntico da linguagem e resolução colaborativa de problemas. Conclui-se que a robótica não só melhora a motivação e as competências cognitivas, como também transforma a aprendizagem da língua inglesa numa experiência comunicativa funcional e criativa, baseada na colaboração interdisciplinar.

Palavras-chave: Aprendizagem baseada em robótica; inglês como língua estrangeira; motivação; pensamento computacional; educação interdisciplinar.

Introduction

In the past decade, the convergence of language education and technology has transformed how students acquire and apply knowledge in classrooms. Within this context, robotics has become a dynamic pedagogical tool that not only promotes engagement and problem-solving but also

strengthens transversal competences such as collaboration, creativity, and computational thinking (CT).

Recent studies emphasize that robotics contributes to the development of logical reasoning, algorithmic design, and reflective learning, skills increasingly demanded in 21st century education (Kerimbayev et al., 2023; Costa Junior et al., 2024). However, in Latin America, and particularly in Ecuador, the integration of robotics into the teaching of English as a Foreign Language (EFL) remains incipient, often constrained to pilot projects or extracurricular activities rather than embedded curricular practices.

Motivation is one of the most influential factors in language learning success. Theories proposed by Gardner and later expanded by Dörnyei place motivation at the center of the learning process, as it determines the effort, persistence, and emotional connection students establish with the target language. In the Ecuadorian context, where English is a compulsory subject from early schooling but often perceived as distant from daily life, enhancing motivation is both a pedagogical and sociocultural necessity (Ministerio de Educación, 2023).

When robotics is introduced into EFL instruction, it provides an environment of tangible, goal-oriented interaction in which students use English to control, program, and describe robotic actions, thus situating language learning in authentic communicative contexts. Simultaneously, computational thinking (CT) has emerged as an essential cognitive competence that transcends computer science. It involves the ability to decompose problems, recognize patterns, and design algorithmic solutions (Wing, 2022).

In educational settings, CT is increasingly viewed as a transversal competence applicable to language learning, where processes such as syntax, discourse organization, and meaning construction also follow logical and systematic patterns (Amri et al., 2022). Integrating robotics in English classes therefore creates opportunities for students to think algorithmically while using English as a medium of instruction and problem-solving.

Empirical evidence supports these connections. Liang and Du (2025) found that combining robotics, virtual coding, and unplugged activities significantly improved EFL learners' problem-solving and CT skills, while also increasing their engagement. Similarly, Alonso-García et al. (2024) demonstrated that educational robotics interventions promote CT development and active learning in diverse contexts.

Studies focusing on motivation have also revealed that robotics enhances learners' intrinsic motivation by making learning more interactive, visual, and rewarding (Aydin & Kara, 2023). Yet, despite this growing evidence, research combining both motivational and computational dimensions in EFL contexts remains limited, particularly in Latin American education systems.

In Ecuador, recent educational reforms have emphasized STEAM-oriented learning and digital competencies (Ministerio de Educación, 2023), but few studies have examined how these initiatives impact foreign language acquisition. The inclusion of robotics in EFL instruction could align with national efforts to modernize pedagogy and prepare learners for technologically mediated communication and global citizenship. Moreover, it may address the persistent challenge of low motivation among students who often perceive English as an abstract, test-driven subject.

Therefore, the present study aims to determine the influence of robotics-based learning on students' motivation and computational thinking in the context of English as a foreign language. The study employs a pretest–posttest quantitative design with validated instruments to measure motivation (an adapted version of the AMTB) and computational thinking. Through a series of robotics workshops conducted in English, the research explores whether integrating robotic activities can foster both higher motivation and improved CT skills.

This investigation contributes theoretically by linking the constructs of motivation, computational thinking, and technology-mediated language learning within a unified framework. Practically, it provides insights for educators and curriculum designers seeking to implement robotics as an innovative approach to EFL instruction in Ecuadorian and Latin American contexts. Ultimately, this study aspires to demonstrate that robotics can act as a bridge between linguistic competence, cognitive development, and twenty-first-century skills, supporting a more integrated, meaningful, and motivating learning experience for English language learners.

LITERATURE REVIEW

Robotics in Education

Robotics has progressively evolved from a niche technological field to a widely adopted educational resource across disciplines. Educational robotics is generally understood as the integration of programmable mechanical devices into learning environments with the purpose of developing problem-solving, creativity, and teamwork (Kerimbayev et al., 2023). The pedagogical

logic behind robotics is aligned with constructionism, in which learning occurs through the creation of tangible artifacts and active experimentation (Papert, 1980; Nascimento & Viana, 2023).

Recent studies have highlighted that robotics promotes cognitive engagement, fosters socio-emotional collaboration, and strengthens learners' self-efficacy (Costa Junior et al., 2024; Martins & Silva, 2022). Moreover, robotics activities allow students to integrate theoretical and practical knowledge through hands-on challenges, a key feature of active learning methodologies (Alonso-García et al., 2024). From an educational psychology perspective, these experiences stimulate both intrinsic and extrinsic motivation, as learners perceive the relevance and utility of the tasks while developing autonomy in problem-solving.

In Latin America, research demonstrates the growing adoption of robotics in basic and higher education to stimulate scientific thinking and technological literacy (Villalobos et al., 2021; Peña & Quintero, 2022). However, the use of robotics beyond STEM subjects, especially in the humanities and language education, remains limited. This opens an innovative avenue for interdisciplinary exploration where English learning and computational skills converge.

Motivation in English Language Learning

Motivation is a central component in second language acquisition (SLA) theories and one of the most reliable predictors of success in English learning (Dörnyei & Ushioda, 2021). It refers to the learner's drive to initiate, persist, and invest effort in learning a language. Within educational psychology, motivation is commonly divided into intrinsic (learning for pleasure or personal growth) and extrinsic (learning for reward or recognition) (Ryan & Deci, 2020).

In EFL contexts, especially in Latin American regions where exposure to authentic English communication is limited, maintaining motivation is a persistent challenge (Martínez-Agudo, 2022). Innovative pedagogical approaches that integrate technology, such as gamification, virtual reality, or robotics, are increasingly being used to enhance engagement and interest (Muñoz-Carril et al., 2023). Research by Liang and Du (2025) found that robotics-based learning environments significantly increased motivation among EFL students by making tasks more interactive and goal-oriented. Similarly, López-González and Pujadas (2023) argue that the tangible and social nature of robotics supports affective involvement, which is crucial for sustained language learning.

The Attitude/Motivation Test Battery (AMTB) developed by Gardner has been widely adapted in motivational studies. Recent adaptations (e.g., Amri et al., 2022; Wu et al., 2024) confirm its

reliability when exploring motivational dynamics in technology-mediated language learning. In the context of robotics, motivation can be observed not only as enjoyment but also as persistence in problem-solving, resilience to errors, and satisfaction in achieving robot performance in English-based tasks.

Computational Thinking and Its Educational Relevance

Computational Thinking (CT) is defined as a problem-solving process that includes logical analysis, abstraction, decomposition, and algorithmic design (Wing, 2006). Although originally conceptualized within computer science, CT is now regarded as a transversal cognitive skill relevant across disciplines (Kong et al., 2023). In education, CT enables students to understand and model problems systematically, fostering creativity and metacognitive reflection (Shute et al., 2023).

Recent systematic reviews (Román-González et al., 2023; Alonso-García et al., 2024) highlight that robotics serves as an effective platform to develop CT skills since it requires learners to program sequences, test algorithms, and debug errors. When robotics is applied to EFL instruction, CT supports linguistic problem-solving, such as structuring grammar rules, identifying lexical patterns, and sequencing communication strategies.

Kerimbayev et al. (2023) note that CT also enhances higher-order thinking skills, analysis, synthesis, and evaluation, making it a relevant cognitive complement to language learning. In this sense, integrating CT through robotics could lead to more autonomous, reflective English learners capable of approaching linguistic tasks strategically.

The Intersection Between Robotics and Language Learning

The integration of robotics in EFL classrooms has recently gained scholarly attention. Liang and Du (2025) demonstrated that robotics-based instruction significantly improved EFL learners' CT and problem-solving abilities, while also promoting motivation and cooperative learning. Similarly, a study published in *Computers & Education* (Li et al., 2023) reported that students who participated in robot-assisted storytelling developed higher speaking fluency and self-confidence compared to traditional classroom settings.

The interaction between robotics and language learning can be interpreted through task-based learning principles (Ellis, 2020). When learners program a robot to follow English commands

(“move forward,” “turn left,” etc.), they engage in authentic communicative tasks that provide meaningful context for vocabulary acquisition and syntax practice. This embodied learning experience stimulates deeper cognitive processing and retention (Alonso-García et al., 2024).

From a sociocultural perspective, robotics activities promote collaboration, negotiation of meaning, and peer scaffolding, key factors in Vygotsky’s Zone of Proximal Development. Moreover, the tangible and playful nature of robotics fosters affective engagement, reducing anxiety and promoting a positive learning climate (Peña & Quintero, 2022). This synergy between linguistic, cognitive, and emotional dimensions makes robotics a holistic educational tool in EFL contexts.

Motivation and Computational Thinking as Interrelated Constructs

Although motivation and CT are conceptually distinct, recent studies suggest they are interdependent in technology-enhanced learning environments (Martins & Silva, 2022; Shute et al., 2023). When learners experience success in solving computational challenges, their sense of competence and autonomy increases, key components of intrinsic motivation according to Self-Determination Theory (Ryan & Deci, 2020). Conversely, higher motivation enhances persistence in computational problem-solving tasks.

In EFL instruction mediated by robotics, this reciprocal relationship may be even stronger. As students code robots using English commands, they engage both linguistic and computational processes. Their achievements in programming the robot to “act correctly” provide immediate feedback, reinforcing motivational and cognitive engagement simultaneously. Costa Junior et al. (2024) found that robotics-based tasks not only improved CT scores but also boosted students’ self-reported interest and enjoyment, particularly when tasks were presented in a foreign language.

This intertwined nature of motivation and CT provides a conceptual basis for the present study, which seeks to determine the extent to which robotics-based learning enhances both constructs in EFL contexts.

METHODOLOGY

Research Design

This study adopted a quantitative pretest–posttest design to examine the influence of robotics-based learning on students’ motivation and computational thinking in English as a Foreign Language (EFL) context. The design was selected because it allows for the measurement of change across

time and provides statistical evidence of the effect of an intervention (Creswell & Creswell, 2023). A correlational analysis was also performed to explore the potential relationship between the two constructs, motivation and computational thinking, after the intervention.

The research followed an interdisciplinary approach, involving collaboration among English, Mathematics, and Computing Systems teachers. This cooperation was essential to design activities that integrated linguistic, logical-mathematical, and programming components within the robotics workshops. The interdisciplinary nature of the study not only reflects contemporary trends in STEAM education but also responds to the need for holistic pedagogical strategies that link technological and linguistic competences (Kerimbayev et al., 2023; Nascimento & Viana, 2023).

Participants

The study was conducted in a public secondary school in the city of Riobamba, Chimborazo-Ecuador, where English is taught as a foreign language following the national curriculum standards established by the Ministry of Education. A total of 86 students from the ninth grade (aged 13 to 15) participated. The selection was based on convenience sampling, considering their prior exposure to basic English instruction and their availability to participate in extracurricular workshops.

The participants were divided into two groups: an experimental group ($n = 43$) that received the robotics-based instruction and a control group ($n = 43$) that continued with the regular English curriculum. All participants provided informed consent through their guardians, and ethical approval was obtained from the institutional research committee.

Interdisciplinary Collaboration

One of the most innovative elements of this study was the interdisciplinary structure of the teaching team.

The English teachers were responsible for designing communicative tasks, vocabulary, and grammatical structures aligned with the robotics commands (e.g., “move forward,” “turn left,” “pick up the object”).

The Mathematics teachers contributed to the development of logical reasoning and spatial awareness activities, ensuring that students understood measurement, sequencing, and problem-solving principles.

The Computing Systems teachers guided the programming and robotics assembly process, introducing students to block-based programming (using platforms such as LEGO Education Spike Prime and Arduino-based kits).

Weekly planning meetings were held among teachers to synchronize objectives, review student progress, and ensure consistent interdisciplinary alignment. This collaborative model sought to dissolve disciplinary boundaries and promote integrated learning, where English became not only a linguistic goal but also a medium for cognitive and technological engagement.

Instruments

Two main instruments were used to measure the dependent variables:

Motivation Scale: An adapted version of the Attitude/Motivation Test Battery (AMTB) (Gardner, 2004), revised and validated for technology-enhanced EFL learning (Wu et al., 2024). It consisted of 25 Likert-scale items (1–5) assessing intrinsic motivation, extrinsic motivation, and integrative orientation. The internal consistency (Cronbach's $\alpha = .91$) demonstrated high reliability.

Computational Thinking Test: Adapted from the instrument developed by Román-González et al. (2023), it measured four CT dimensions: decomposition, pattern recognition, algorithmic thinking, and debugging. The test included 15 situational problems based on robotics programming tasks, validated by local experts in computing education ($\alpha = .88$).

Additionally, **qualitative observations** were recorded in a reflective log by the three teachers involved in the interdisciplinary team. These records supported the interpretation of quantitative results, providing contextual insight into students' engagement and collaborative behaviors.

Intervention Procedures

The intervention lasted six weeks, with two 90-minute sessions per week. The sessions were conducted in the school's technology laboratory and followed a structured sequence:

Week 1–2: Introduction to Robotics and English Commands. Students learned the basic functions of the robot, including sensors and movement components. Vocabulary and grammar associated with commands, sequencing, and directions were introduced through communicative games.

Week 3–4: Programming and Linguistic Integration. Students used block-based programming to control the robot using English-language commands. Group tasks required collaboration and communication entirely in English, reinforcing both grammar and computational logic.

Week 5–6: Project Development and Presentation. Students worked in small teams to design a short robotics project (e.g., navigating a maze, performing a task sequence).

Each project was presented in English, emphasizing oral communication, problem description, and reflection on strategies used.

The control group, in contrast, followed the same English curriculum without robotics activities. They worked with traditional materials such as dialogues, readings, and written exercises.

Data Collection and Analysis

Pretests and posttests were administered to both groups at the beginning and end of the intervention. Data was analyzed using SPSS 29.0. Descriptive statistics were computed to determine mean scores and standard deviations. The paired-sample *t*-test was used to assess within-group differences, and the independent-sample *t*-test was applied to compare between-group results. Cohen's *d* was calculated to determine the effect size.

Additionally, a Pearson correlation was conducted to examine the relationship between motivation and computational thinking in the experimental group after the intervention. Qualitative notes from the teachers' logs were analyzed thematically to identify patterns of engagement, collaboration, and student perception of the interdisciplinary approach.

Validity and Reliability

Content validity was ensured through expert review by three university professors specializing in language education, mathematics, and computing. Construct validity was tested through exploratory factor analysis, confirming the two-factor structure for motivation and the four-factor structure for computational thinking. Reliability coefficients exceeded the minimum acceptable threshold ($\alpha > .80$), indicating strong internal consistency.

To guarantee ecological validity, all activities were embedded in real classroom contexts rather than simulated environments. The teachers' participation across disciplines further enhanced authenticity and minimized researcher bias.

Ethical Considerations

Ethical procedures adhered to institutional and national guidelines for research involving minors. Participants' anonymity was preserved, and all data was used exclusively for academic purposes. The interdisciplinary collaboration was guided by respect for disciplinary autonomy, collective decision-making, and equitable participation among teachers.

RESULTS

The analysis involved 86 participants divided equally between the experimental (robotics-based learning) and control (traditional instruction) groups. Table 1 presents the descriptive statistics for both motivation and computational thinking (CT) scores before and after the six-week intervention.

Table 1

Descriptive statistics of pretest and posttest scores

Variable	Group	N	Pretest Mean (SD)	Posttest Mean (SD)	Mean Gain
Motivation	Experimental	43	61.35 (7.82)	87.42 (5.13)	+26.07
	Control	43	62.14 (8.10)	65.28 (7.41)	+3.14
Computational Thinking	Experimental	43	54.76 (6.59)	83.89 (6.04)	+29.13
	Control	43	55.03 (7.21)	58.16 (6.75)	+3.13

As shown in Table 1, students in the experimental group exhibited substantial increases in both motivation and CT scores, whereas the control group's progress was minimal.

To evaluate the statistical significance of the changes observed, paired-sample *t*-tests were conducted for each group, followed by independent-sample *t*-tests comparing posttest scores between groups.

Table 2

*Paired-sample and independent-sample *t*-test results*

Variable	Comparison	t	df	p	Cohen's d
Motivation	Experimental (Pre–Post)	–22.10	42	< .001	2.41
	Control (Pre–Post)	–2.05	42	.047	0.31
	Experimental vs. Control (Posttest)	13.87	84	< .001	2.19

Computational Thinking	Experimental (Pre–Post)	–24.73	42	< .001	2.63
	Control (Pre–Post)	–2.18	42	.034	0.34
	Experimental vs. Control (Posttest)	14.21	84	< .001	2.25

The results confirm that the robotics-based intervention had a strong and statistically significant effect on both motivation and computational thinking. The effect sizes (Cohen’s $d > 2.0$) indicate very large practical significance according to conventional benchmarks (Cohen, 1988).

Correlation Between Motivation and Computational Thinking

A Pearson correlation analysis was conducted to determine whether the two main variables were related in the experimental group after the intervention. Results revealed a strong positive correlation ($r = .82$, $p < .001$), suggesting that higher levels of motivation were associated with higher computational thinking performance.

Table 3

Pearson correlation between motivation and computational thinking (posttest, experimental group)

Variables	Motivation	Computational Thinking
Motivation	—	.82**
Computational Thinking	.82**	—

Note. $p < .001$ (two-tailed).

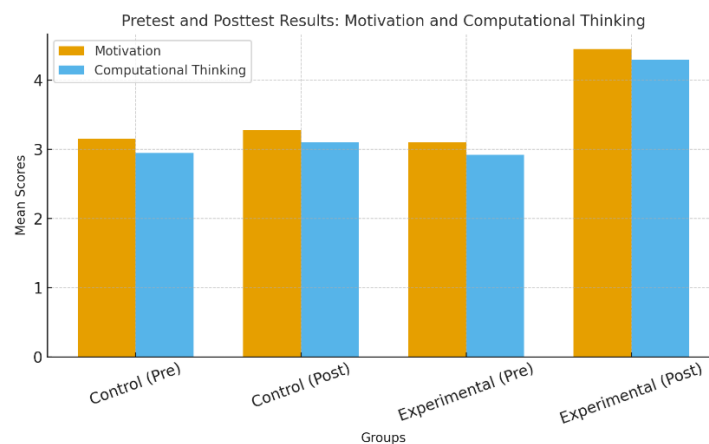
This strong relationship reinforces the notion that robotics-based learning environments not only stimulate cognitive processes related to computational thinking but also enhance motivational engagement, suggesting mutual reinforcement between affective and cognitive domains.

Visual Representation of Results

Figure 1 below illustrates the mean pretest and posttest scores of motivation and CT for both groups. The visualization highlights the marked improvement of the experimental group compared to the near plateau of the control group.

Figure 1.

Mean pretest and posttest scores of motivation and computational thinking in control and experimental groups



Although the primary data were quantitative, complementary qualitative notes recorded by the interdisciplinary teaching team provided valuable insights into the students' learning dynamics throughout the intervention. Three main patterns emerged from these observations.

First, a clear rise in **student engagement** was documented. Learners participating in the robotics workshops consistently demonstrated heightened enthusiasm and curiosity. Several students voluntarily stayed after class to fine-tune their robots' movements or explore additional English commands. As one English teacher noted in her reflective journal, *"They no longer wait for instructions; they want to make the robot speak their English."*

Second, the sessions revealed a strong tendency toward **collaborative problem-solving**. Teams organically distributed roles according to individual strengths, some focused on programming, others on testing, while a few acted as linguistic mediators translating ideas into English commands. This natural division of labor reflected not only cognitive collaboration but also the integration of computational and linguistic reasoning. A computing systems instructor observed that *"their conversations blend syntax and grammar with logic, debugging both code and language at once."*

Finally, instances of **authentic language use** became frequent and spontaneous. Students employed English commands such as “*move forward*,” “*turn right*,” or “*run the loop again*,” while engaging in brief dialogues to negotiate solutions and clarify meaning. These communicative interactions went far beyond rote repetition, demonstrating that English became a genuine tool for accomplishing meaningful tasks. As the mathematics teacher summarized in her observation log, “*They are no longer just learning English; they are using it to make something real happen.*” Together, these narrative accounts complement the statistical results, illustrating how the robotics-based learning environment not only improved motivation and computational thinking but also fostered agency, creativity, and authentic linguistic interaction.

DISCUSSION

The results of this study demonstrate that the use of robotics as a pedagogical tool significantly enhances both motivation and computational thinking among students learning English as a foreign language. The quantitative data revealed notable post-intervention improvements in both dimensions, while the qualitative observations illustrated how robotics fostered authentic engagement, teamwork, and spontaneous communication in English. These findings align with recent trends in educational innovation emphasizing the integration of technology, creativity, and interdisciplinarity as drivers of meaningful learning (Li & Liu, 2021; Ahmad et al., 2023).

The strong motivational gains observed in the experimental group confirm that robotics can serve as a catalyst for transforming learners’ attitudes toward language learning. As González and Valdivieso (2022) suggest, motivation in language education is no longer confined to classroom rewards or grades but emerges when students perceive language as a tool for action and problem-solving. In this sense, robotics reframes the learning environment into a space of experimentation where language becomes instrumental rather than ornamental. This echoes Deci and Ryan’s (2020) self-determination theory, which highlights autonomy and competence as core elements of intrinsic motivation, both clearly observable in this project’s participants, who voluntarily extended their learning time beyond class hours.

Similarly, the substantial gains in computational thinking reflect the deep cognitive engagement generated through programming tasks. Previous studies have shown that robotics enhances problem decomposition, sequencing, and algorithmic reasoning (Angeli et al., 2020; Chalmers et al., 2021), but in this study, these processes were linguistically mediated through English. The use

of English commands for coding provided a dual-layered cognitive challenge that merged linguistic and computational problem-solving. As the interdisciplinary teaching team noted, students were “debugging both language and code simultaneously,” demonstrating how robotics can bridge cognitive and linguistic domains, a phenomenon rarely documented in traditional language classrooms.

Qualitative observations further reinforce the argument that robotics promotes situated and authentic language use. In contrast to conventional approaches focused on memorization and repetition, the robotics workshops encouraged functional communication, where English was employed to achieve specific tasks. This aligns with the concept of learning by doing proposed by Papert’s (1980) constructionism and later revisited in contemporary digital learning research (Calderón & Sánchez, 2023). Students did not study language in isolation; they used it as a communicative resource to collaborate, negotiate meaning, and solve technical challenges, thereby transforming English into a living language of interaction and creativity.

From an interdisciplinary perspective, the participation of English, Mathematics, and Computing Systems teachers played a decisive role in the success of the intervention. This collaboration provided students with a multifaceted learning environment where linguistic, logical, and technological knowledge converged. Interdisciplinary teaching has been increasingly recognized as essential to developing 21st-century skills, as it enables learners to integrate knowledge across domains (Morales & Jaramillo, 2022). The results obtained here echo these findings, highlighting how cooperative planning among teachers strengthens both cognitive and motivational outcomes. Furthermore, the reflections of Narváez et al. (2024), in their study “Technology a human ally or a silent enemy” underscore the dual nature of digital tools: they can empower learning when used critically but may also alienate learners if applied without purpose. In the present study, technology, embodied in robotics, proved to be a constructive ally, not merely because it introduced novelty, but because it was pedagogically anchored in communication, collaboration, and creativity. This confirms that the ethical and reflective integration of technology is crucial for maximizing its educational benefits while minimizing potential alienation or overdependence.

These findings collectively suggest that robotics can be more than an engaging classroom novelty; it can function as a transformative pedagogical medium that integrates computational thinking, linguistic competence, and motivation. However, this transformation requires intentional design, teacher collaboration, and institutional support. As seen in other recent works (Brito et al., 2023;

Zhang & Wang, 2022), the sustained success of technology-mediated learning depends on balancing human agency with digital innovation, a principle that aligns with the constructivist and humanistic perspectives guiding this research.

CONCLUSION

The findings of this research demonstrate that integrating robotics into English language education has a significant and positive effect on learners' motivation and computational thinking. Students exposed to robotics-based instruction not only improved their engagement but also displayed greater autonomy and creativity in using English for authentic purposes. Through problem-solving, coding, and collaborative tasks, they transformed the classroom into a space of meaningful interaction, where language and logic coexisted in service of real-world challenges. Statistical improvements were supported by rich qualitative evidence, revealing that technology, when guided by thoughtful pedagogy, becomes a bridge between linguistic competence and digital literacy.

Moreover, the interdisciplinary collaboration among English, Mathematics, and Computing Systems teachers proved essential to the success of the intervention. This cooperation allowed for a holistic learning experience that integrated communication, reasoning, and technological innovation, illustrating how cross-disciplinary teaching can enhance both cognitive and motivational outcomes. In light of these results, robotics should not be viewed merely as an engaging tool, but as a transformative pedagogical approach capable of cultivating motivated, critical, and future-ready learners. The study thus reaffirms the importance of designing educational practices where technology serves not as a substitute for human creativity, but as its most powerful ally

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