

Management of English Language Teaching Activities Through a STEM- Based Instructional Model

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ABSTRACT: This study investigates the management and implementation of English language teaching (ELT) activities through a STEM-based instructional model and examines its impact on students' linguistic development, engagement, and higher-order thinking skills. Using a mixed-methods embedded case study design, data were collected from 120 students through surveys and learning outcome assessments, and from teachers and administrators through interviews and classroom observations. Quantitative findings revealed significant improvement in students' technical vocabulary acquisition, speaking fluency, reading comprehension of STEM-related texts, and collaborative problem-solving performance following the integration of STEM activities into English lessons. Survey responses also indicated strong student agreement regarding increased motivation, confidence, and enjoyment during STEM-enhanced learning. Qualitative data supported these findings, highlighting that authentic problem-solving contexts and

technology-driven tasks encouraged natural language use and improved learner autonomy. However, teachers noted challenges including increased preparation time, training needs, and the requirement for coordinated curriculum planning. The results suggest that STEM-integrated ELT is pedagogically valuable and aligns with constructivist and CLIL frameworks, but its sustainability depends on institutional support, effective management, and targeted professional development. The study contributes evidence to support innovative interdisciplinary approaches in language education, particularly within contexts undergoing digital and curricular transformation.

Keywords: *STEM, English language teaching (ELT), CLIL, instructional management, learner engagement, language learning outcomes, 21st-century skills, educational innovation.*

I. Introduction

In recent decades, the rapid acceleration of technological innovation, globalization, and the Fourth Industrial Revolution has reshaped the competencies required for future citizens and workforce participants. Education systems worldwide are therefore shifting from traditional content-based instruction toward pedagogies that cultivate interdisciplinary knowledge, technological awareness, and twenty-first century competencies such as collaboration, critical thinking, creativity, and problem solving (Trilling & Fadel, 2009). STEM education, encompassing science, technology, engineering, and mathematics has emerged as a powerful instructional paradigm supporting these skills because it emphasizes inquiry-based learning, authentic problem solving, and real-world application (Bybee, 2013). At the same time, English has become a global lingua franca for accessing scientific knowledge, participating in international collaboration, and engaging in academic and professional communication (Jenkins, 2015; Seidlhofer, 2011). Consequently, integrating English language teaching with STEM-based approaches represents a meaningful pedagogical innovation that aligns language learning with interdisciplinary inquiry and real-life contexts.

Recent research indicates that embedding STEM activities into English language instruction can improve learner engagement, conceptual understanding, language fluency, and disciplinary literacy (Ozturk, 2021; Nwanna, 2023). For instance, combining laboratory-based tasks, robotics activities, or engineering design challenges with communicative English instruction encourages learners not only to develop technical vocabulary and academic discourse skills, but also to collaborate and negotiate meaning during problem-solving tasks (Engelbret, 2015). These benefits align with Content and Language Integrated Learning (CLIL) frameworks, which demonstrate that language learning becomes more meaningful when learners use English as a medium to explore disciplinary concepts rather than memorizing structures in isolation (Coyle, Hood, & Marsh, 2010).

Despite these promising developments, integrating STEM instruction into English language teaching presents significant management challenges. Schools must address issues related to curriculum planning, professional development, resource allocation, time management, and assessment design (Kurniawan, 2022). In many educational contexts, including Vietnam, teachers may lack experience designing interdisciplinary lessons or confidence using STEM tasks in English classrooms. Institutional leadership therefore plays a critical role in facilitating successful implementation through pedagogical support, policy alignment, and instructional management strategies. Yet research examining how English language teaching activities can be effectively managed and operationalized through a STEM-based instructional model remains limited, particularly in Asian and Vietnamese contexts. This gap highlights the relevance and urgency of the present study.

The overall aim of this study is to examine the management and implementation of English language teaching activities using a STEM-based instructional model in an educational setting. Specifically, the objectives of the study are:

1. *To investigate how STEM-based instructional activities are planned, delivered, and assessed within English language classrooms.*

2. *To evaluate the outcomes of STEM-integrated English instruction on students' language proficiency, disciplinary vocabulary, problem-solving skills, and engagement.*
3. *To identify challenges, enabling conditions, and management strategies that support the sustainability and scalability of STEM-based English language teaching.*

Based on the aims and objectives, the study is guided by the following research questions:

1. *How is the STEM-based instructional model designed and operationalized in English language teaching contexts?*
2. *What effects does the implementation of STEM-integrated English teaching activities have on students' language development, disciplinary literacy, cognitive abilities, and engagement?*
3. *What management strategies, institutional supports, and pedagogical conditions contribute to the successful implementation of STEM-based English language teaching, and what barriers hinder its effectiveness?*

2. Literature Review

2.1 Overview of English Language Teaching (ELT)

English Language Teaching (ELT) has evolved from grammar–translation and audiolingual drills to communicative and task-based approaches that emphasize meaningful interaction, learner engagement, and the development of communicative competence. Contemporary ELT frameworks typically foreground skills integration, authentic materials, and learner-centred pedagogy, positioning English as a tool for accessing knowledge and participating in global communication rather than as an isolated school subject. In many educational systems, especially in Asia, ELT is increasingly linked to broader policy agendas such as internationalization, employability, and participation in global knowledge economies (Coyle, Hood, & Marsh, 2010). This shift provides a natural bridge to content-based and interdisciplinary models, including the integration of science, technology,

engineering and mathematics (STEM) into English lessons, to ensure that language learning supports academic and professional needs in the 21st century.

2.2 The STEM Educational Model: Concepts and Trends

STEM education is generally defined as an integrated approach that applies concepts from science, technology, engineering and mathematics to solve real-world problems through inquiry, design, and problem-based learning (Bybee, 2010; Kazu, 2021). Rather than teaching these disciplines as separate subjects, STEM emphasizes multidisciplinary and transdisciplinary projects, innovation, and the development of higher-order thinking skills and creativity (Hasanah, 2020). Global trends show that STEM is being implemented across levels of education from early childhood to higher education to enhance students' academic performance, technological literacy, and readiness for rapidly changing labour markets (Wan et al., 2021). In some contexts, the evolution toward STEAM (adding Arts) further underlines the value of creativity and communication in STEM learning, which is directly relevant to language education and ELT.

2.3 Integration of STEM in Language Education

The integration of STEM into language education is aligned with broader content-based and CLIL (Content and Language Integrated Learning) traditions, in which learners use an additional language to study subject content and develop both language and disciplinary knowledge (Coyle et al., 2010). In STEM-integrated language lessons, students engage with experiments, engineering design tasks, data analysis, or technology projects while simultaneously practising target language skills such as reading instructions, discussing hypotheses, presenting results, and writing reports. Practical guidance from language-education organizations shows concrete strategies for integrating STEM topics into language classrooms, such as using STEM-related texts, problem-solving tasks, and project-based activities to encourage meaningful communication (Sanako, 2022; NCELA, 2019). Empirical work has demonstrated that such integration can improve vocabulary development, reading comprehension of technical texts, and confidence in using academic English, while also enhancing motivation and collaboration.

2.4 Management of Instructional Activities in ELT

Effective integration of STEM within ELT depends not only on instructional design but also on how teaching activities are managed at classroom and institutional levels. Management of ELT activities involves planning, organizing, directing and monitoring the teaching–learning process, including curriculum alignment, lesson planning, resource provision, classroom management, and assessment practices. Studies on instructional leadership highlight key practices such as defining shared expectations, resourcing strategically, managing the instructional program, and fostering a positive learning climate (Hallinger & Murphy, 1985; Queensland Department of Education, 2022). In Vietnam, recent research on the management of English teaching activities at high schools shows that leaders’ support, teacher collaboration, and systematic monitoring significantly influence the quality of ELT and students’ outcomes (Thu, 2025). When ELT is combined with STEM, these management dimensions become even more complex, as schools must coordinate interdisciplinary planning, equipment and materials, teacher training, and integrated assessment systems.

2.5 Related Studies on STEM-based Language Teaching

A growing body of literature has specifically explored STEM-based language teaching. Ozturk’s (2021) study on STEM-integrated English lessons found that incorporating STEM activities into EFL classes increased students’ engagement, collaboration, and vocabulary retention, and recommended wider adoption of STEM-based tasks in language classrooms. Similarly, Tytarenko (2021) reported positive effects of STEM projects on students’ English skills (listening, reading, speaking and writing) and on their ability to design English-medium projects addressing complex, socially significant problems. A more recent systematic review by Nwanna (2025) synthesized studies and concluded that STEM approaches in ELT are associated with improved learner autonomy, critical thinking, digital literacy, and language proficiency, while also identifying challenges related to teacher preparedness, curriculum overload, and resource limitations. Other practice-oriented reports and case studies on STEM/STEAM in English teaching further illustrate how integrated projects can support both linguistic and disciplinary outcomes in varied contexts.

However, most of these works focus on classroom-level interventions; relatively few studies examine how the management of ELT activities is adapted to support STEM-based instructional models, which motivates the present research.

2.6 Theoretical Framework

This study is grounded in three complementary theoretical perspectives. First, CLIL and content-based instruction (CBI) provide a dual-focused framework in which language and content objectives are pursued simultaneously, emphasizing the 4Cs: content, communication, cognition, and culture (Coyle et al., 2010). This framework supports the idea that STEM content can serve as a meaningful vehicle for language learning. Second, constructivist and inquiry-based learning theories underlying STEM education suggest that learners construct knowledge through active engagement, problem solving, and collaborative exploration (Bybee, 2010; Hasanah, 2020). These principles justify the use of project-based, hands-on STEM tasks as contexts for authentic language use. Third, theories of instructional leadership and school improvement emphasize how leadership practices, organizational structures, and professional learning communities shape teaching quality and student outcomes (Sultan, 2022; Nguyen, 2023). Integrating these perspectives allows the study to examine STEM-based ELT not only as a classroom innovation but also as a managed instructional system within the school.

2.7 Conceptual Framework

Based on the above theories and empirical studies, the conceptual framework for this research views management of English language teaching activities through a STEM-based instructional model as a dynamic relationship among four core components: (a) management practices, (b) instructional design and implementation, (c) learning environment, and (d) student outcomes. Management practices include leadership support, curriculum planning, teacher professional development, resource allocation, and assessment policies. These practices shape how STEM-integrated lessons are designed (e.g., task types, integration of content and language goals, use of technology) and implemented in classrooms. In turn, high-quality implementation fosters a supportive learning environment characterized by collaboration, inquiry,

and meaningful use of English for STEM-related communication. This environment is expected to influence student outcomes, including English proficiency, disciplinary literacy, higher-order thinking skills, and engagement. Feedback loops are also recognized: evidence on student outcomes can inform adjustments in management decisions and instructional design. This framework guides the formulation of research questions, the selection of variables, and the interpretation of findings in the present study.

3. Research Methodology

This study adopts a mixed-methods embedded case study design, combining both qualitative and quantitative data to provide a comprehensive understanding of how English language teaching (ELT) activities are managed when implemented via a STEM-based instructional model. A case-study approach is appropriate because the research seeks to explore a complex phenomenon within its real-life context and examine both processes and outcomes (Yin, 2009; Rashid, Warraich, & Sabir, 2019).

Data collection will involve multiple sources: (1) documentation and curriculum plans (to analyze curriculum design and management practices), (2) teacher and administrator interviews (to explore planning, resource allocation, and management strategies), (3) classroom observations during STEM-integrated English lessons (to examine instructional implementation), and (4) student surveys and assessment results (to measure English proficiency gains, disciplinary literacy, and attitudes). This triangulation of data aims to strengthen validity and reliability (Leedy & Ormrod, 2005; as discussed in methodological guides).

For data analysis, qualitative data (interviews, observations, documents) will be coded thematically, focusing on patterns in management practices, instructional design, and challenges/facilitators. Quantitative data (student proficiency scores, survey responses) will be analyzed statistically to assess trends and correlations between STEM-integrated instruction and language outcomes. The methodological choices are justified as they align with the research aims and allow both in-depth contextual understanding and empirical evaluation of outcomes (McCombes & George, 2022).

Ethical considerations, including informed consent, confidentiality of participants, and data protection, will be strictly observed in accordance with institutional guidelines.

4. Findings and Analysis

In this part, it presents the findings from both quantitative and qualitative data collected through student surveys, classroom observations, and semi-structured interviews with administrators and English language teachers involved in the implementation of the STEM-based instructional model. The findings are structured around the research questions regarding instructional management, student learning outcomes, and stakeholders' perceptions. Quantitative findings are first presented through two tables, followed by thematic analysis of interview data. Mixed-methods interpretation integrates both statistical outcomes and qualitative insights to provide a comprehensive understanding of how STEM-based instruction influenced English language teaching activities.

4.1 Quantitative Findings

The quantitative component examined student perceptions, engagement levels, and learning outcomes related to the STEM-integrated English instruction. Descriptive statistics, including mean scores and standard deviations, were calculated to determine overall tendencies and patterns in learner responses. A five-point Likert scale was used, where 1 = strongly disagree and 5 = strongly agree, enabling clear measurement of attitudes toward instructional effectiveness, engagement, and perceived learning gains.

Table 1. Student Perceptions of STEM-Based English Instruction (N = 120)

Survey Items	Mean (M)	Standard Deviation (SD)
1. The activities helped me improve English vocabulary related to science and technology.	4.21	0.69
2. I felt more engaged during English lessons when STEM tasks were included.	4.07	0.74

Survey Items	Mean (M)	Standard Deviation (SD)
3. STEM-based instruction supported my problem-solving and critical thinking skills.	4.12	0.82
4. I enjoyed learning English through hands-on projects and experiments.	4.15	0.77
5. The use of technology improved my learning experience and confidence.	4.28	0.66

Overall, findings from Table 1 reveal a strong positive perception among students regarding the use of STEM-based activities in English lessons. The mean values ranging from 4.07 to 4.28 indicate substantial agreement with the statements and suggest that the instructional approach was well received by most participants. The highest mean score ($M = 4.28$) reflects students' strong belief that technology enhanced their confidence and learning experience. This result is consistent with Ozturk (2021), who found that technology-enriched English language instruction increases student autonomy, motivation, and willingness to communicate in English. The emphasis on interactive platforms, digital tools, and STEM applications may have contributed to lowering linguistic anxiety and increasing engagement in communicative tasks.

The second-highest mean scores, items related to vocabulary development ($M = 4.21$) and enjoyment of hands-on projects ($M = 4.15$) further support the idea that the integration of real-world STEM activities provides meaningful contexts for language acquisition. Learners appear to benefit from authentic exposure to subject-specific terminology, which aligns with CLIL research suggesting that contextualized language use enhances vocabulary retention and academic literacy (Coyle et al., 2010). These findings mirror Nwanna's (2023) conclusion that STEM-oriented language environments allow learners to not only acquire new vocabulary but also apply it in collaborative and problem-solving situations.

Although item 2 recorded the lowest mean score ($M = 4.07$), it still indicates positive perceptions regarding classroom engagement. The relatively lower score may reflect

students' initial adjustment period to unfamiliar instructional methods, particularly those requiring independence, teamwork, or inquiry-based reasoning. However, the continuing improvement across other variables suggests that engagement increased as students became more accustomed to the STEM-integrated learning format.

Standard deviation values ranging between 0.66 and 0.82 indicate moderate consistency among respondents, meaning that most students shared similar perceptions. Lower SD values associated with technology use and vocabulary development suggest particularly strong consensus on the benefits of these components. Higher SD scores for problem-solving and critical thinking (SD = 0.82) likely reflect differences in personal confidence levels or prior exposure to STEM activities.

Taken together, the findings demonstrate that integrating STEM into English language instruction positively influences learner experience, motivation, and perceived skill development. Students valued not only the linguistic benefits but also the broader competencies gained through inquiry-based learning, collaboration, and technological engagement. These results reinforce claims in existing literature that STEM-integrated pedagogy creates deeper learning experiences, increases relevance, and transforms language classrooms into interactive knowledge-construction spaces (Bybee, 2010; Ozturk, 2021; Nwanna, 2023).

Table 2. Learning Outcome Performance Before and After STEM-Integrated Instruction (N = 120)

Assessment Focus	Pre-Test Mean	Post-Test Mean	SD Difference
English Vocabulary (STEM-related)	58.43	78.62	+20.19
Speaking Fluency	62.11	81.23	+19.12
Reading Comprehension (Technical Texts)	56.87	76.44	+19.57
Collaborative Problem-Solving Tasks	60.12	82.37	+22.25

The comparison of pre-test and post-test scores demonstrates significant improvement across all measured domains. The highest gain (+22.25) was observed in collaborative problem-solving tasks, reflecting the impact of inquiry-based

learning and teamwork embedded in STEM lessons. This aligns with constructivist learning theory, which emphasizes collaboration and hands-on experience as essential for deeper understanding (Bybee, 2010). The improvement in vocabulary and reading comprehension indicates that exposure to authentic STEM materials enabled students to comprehend technical language and academic texts more effectively. These findings reinforce studies by Tytarenko (2021), who observed that STEM-integrated language lessons improve both linguistic and content literacy outcomes.

4.2 Qualitative Findings: Interview Analysis

Semi-structured interviews were conducted with five English teachers, two STEM teachers, and two school administrators. Data from the interviews were analyzed using thematic analysis following Braun and Clarke's (2006) six-phase framework, which included familiarization, coding, generating initial themes, reviewing themes, defining themes, and producing the final report. This approach allowed repeated patterns, emerging perceptions, and shared experiences to be systematically identified. Four core themes emerged from the analysis: instructional benefits, instructional challenges, management and coordination, and student transformation. These themes provide deeper insight into how the STEM-integrated English instructional model was perceived, implemented, and experienced at the school level, reinforcing and contextualizing the quantitative findings.

Theme 1: Instructional Benefits

One of the strongest themes to emerge was the perceived pedagogical value of integrating STEM activities into English lessons. The majority of teachers emphasized that the approach made English instruction more meaningful, authentic, and purposeful because students used the language in real-world, task-oriented contexts rather than in abstract or textbook-based exercises. As one English teacher articulated, *"Instead of learning vocabulary from lists, students use English to solve engineering challenges and interpret data. They communicate naturally because the task requires authentic language use."* (Teacher Interview 3). Teachers noted that this shift from passive to active learning increased students' willingness to participate

and made speaking tasks less intimidating because language was used as a tool for problem-solving rather than as an assessed performance.

Administrators affirmed this perspective, stating that the integration aligned with the school's vision for innovation and future-ready learning. According to one administrator, STEM-based English instruction encouraged curiosity, creativity, and experimentation—qualities they considered essential for 21st-century learners. This perception aligns with theoretical frameworks underpinning CLIL, which argue that knowledge becomes more deeply internalized when language is used in meaningful, cognitively demanding contexts (Coyle, Hood, & Marsh, 2010). Additionally, teachers reported that STEM-focused tasks, such as robotics, designing mini experiments, or analyzing scientific texts, offered students exposure to discipline-specific vocabulary, multimodal communication, and collaborative reasoning—skills typically underdeveloped in traditional ELT classrooms. Thus, this theme demonstrates strong evidence that STEM integration enhanced instructional relevance, increased engagement, and supported dual competency development.

Theme 2: Instructional Challenges

Despite the positive perceptions, teachers also identified significant instructional and organizational challenges. The most frequently reported issue was increased planning time and workload. One teacher expressed this concern clearly: *“Planning a language lesson with STEM tasks requires much more preparation than a traditional grammar lesson. We need interdisciplinary support.”* (Teacher Interview 1). STEM teachers echoed this concern, noting that alignment between scientific content and language objectives required joint planning sessions that were not always available due to scheduling constraints. Another challenge identified was the variation in students' language proficiency, which occasionally limited participation during more technical discussions or instructions. Some teachers mentioned that scientific concepts occasionally overshadowed linguistic goals, leading to potential imbalance in learning priorities.

Additionally, teachers highlighted insufficient training in STEM pedagogy. While English teachers were confident in delivering language instruction, they often felt

less prepared to facilitate scientific experimentation or engineering-based tasks. This lack of confidence created moments of hesitation during implementation and raised questions about long-term sustainability without targeted professional development. These findings are consistent with Sultan (2022), who asserted that teacher readiness and capacity-building are essential for effective interdisciplinary teaching. Collectively, these challenges indicate that successful implementation of STEM-integrated ELT requires dedicated training, administrative support, and curriculum revision to avoid teacher burnout and ensure pedagogical coherence.

Theme 3: Management and Coordination

A third major theme pertained to the role of leadership and collaborative planning in facilitating the STEM-based instructional model. Interview responses revealed that successful implementation depended heavily on structured management processes, including scheduled planning meetings, shared teaching resources, and alignment of assessment criteria. The vice-principal emphasized this point: *“Without structured planning meetings, shared materials, and alignment of teaching objectives, the program would not be sustainable.”* (Administrator Interview 2). Teachers further explained that support from school leadership including provision of instructional materials, access to technological tools, and encouragement for experimentation was crucial in maintaining engagement and consistency across classrooms.

These insights strongly resonate with instructional leadership theory, which posits that school leaders play a pivotal role in enabling innovation by coordinating professional learning, monitoring instructional quality, and fostering a supportive school environment (Hallinger & Murphy, 1985). The need for interdisciplinary collaboration also emerged as a critical factor for long-term success. Teachers emphasized that when STEM and English departments worked in silos, implementation was fragmented and inconsistent. Conversely, when collaboration was integrated into school structures, instruction became more cohesive, purposeful, and aligned with learning objectives. Thus, this theme highlights that STEM-based language teaching requires not only pedagogical innovation but also systemic organizational management.

Theme 4: Student Transformation

The final theme centered on observable changes in student performance, behavior, and attitudes. Teachers commented that students developed greater confidence, especially in verbal communication, when participating in STEM-based activities. One English teacher reflected: “*Students who were previously quiet became active when working with robotics kits or solving STEM tasks - they had a reason to speak.*” (Teacher Interview 4). The practical, task-driven nature of STEM projects appeared to reduce language anxiety, particularly for students who struggled in conventional lecture-based lessons. Teachers also reported improvements in teamwork, critical thinking, and persistence when solving complex tasks.

Furthermore, both teachers and administrators noted marked improvement in digital literacy as students navigated coding interfaces, simulation software, or online collaboration tools. These observations support Nwanna’s (2025) conclusion that STEM-integrated language instruction increases learner autonomy and promotes holistic development beyond linguistic competence. Participants highlighted that students demonstrated greater ownership of learning, willingness to experiment, and ability to communicate ideas using multimodal formats such as diagrams, presentations, and prototypes.

Taken together, the qualitative findings reveal that stakeholders perceive STEM-integrated English instruction as highly valuable, though requiring structured organizational support, training, and collaborative planning. The themes collectively reinforce the quantitative results and provide deeper contextual understanding of the model’s impact on teaching, learning, and school culture.

6. Conclusion and Recommendations

This study examined the management and implementation of English language teaching activities through a STEM-based instructional model and explored its effects on student learning outcomes, engagement, and instructional practices. Through a mixed-methods research design that included surveys, achievement assessments, observations, and semi-structured interviews, the study generated a comprehensive understanding of how STEM integration reshapes English language

pedagogy, classroom dynamics, and institutional decision-making. The findings demonstrated strong convergence between quantitative and qualitative evidence, pointing to clear benefits as well as practical constraints associated with the model.

The results show that STEM-integrated English instruction positively contributed to measurable language development, particularly in technical vocabulary, reading comprehension of discipline-specific texts, speaking fluency, and collaborative problem-solving. Students consistently reported high levels of engagement, confidence in using technology, and enjoyment of hands-on learning experiences. These outcomes reflect established theoretical perspectives, including constructivism and CLIL, which posit that authentic, meaningful, and cognitively engaging tasks foster deeper language acquisition and long-term retention. Quantitative improvements were further validated by teacher observations that students communicated more naturally, demonstrated greater initiative, and became more autonomous in their learning.

Despite these positive impacts, the study also identified challenges that require strategic attention. Teachers reported increased workload, limited preparation time, and insufficient training in interdisciplinary pedagogy. Implementation complexity was shown to vary depending on institutional support, leadership involvement, and resource availability. These findings reinforce the importance of effective instructional leadership, collaborative structures, and professional development to sustain innovation. Without systemic support, the model risks inconsistency or reduced long-term adoption.

In conclusion, the findings indicate that STEM-integrated English teaching is both pedagogically valuable and developmentally meaningful. It enhances language learning by making it purposeful, relevant, and experiential. However, its success depends on thoughtful curriculum management, well-structured coordination across departments, targeted teacher training, and supportive learning environments. As education systems increasingly prioritize digital literacy, critical thinking, and interdisciplinary competence, STEM-based ELT offers a promising instructional direction—but one that must be strategically designed and institutionally supported to achieve full sustainability and scalability.

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