Integrating Technology-Based Instruction and Mathematical Modelling for STEAM-Based Language Learning: A Sociocultural and Self-Determination Theory Perspective

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Abstract—This paper presents a conceptual framework that combines technology-based instruction and mathematical modeling in a STEAM-oriented approach to enhance the English language acquisition of Malaysian students. The proposed framework consists of a six-month English as a Foreign Language program that integrates technology and mathematical simulation in a STEAM-oriented methodology. The exercises are designed to enhance linguistic competence, with a focus on improving listening, speaking, reading, and writing skills. The framework aims to foster a positive learning environment that encourages self-determination and promotes sociocultural interaction. The integration of technology-enabled instruction and mathematical modeling offers a viable strategy for enhancing the language competency of non-native English speakers. However, further research and empirical analysis are necessary to evaluate the impact of this framework on academic performance. Despite this limitation, the proposed framework offers a promising approach to address the challenges faced by less proficient Malaysian students in acquiring English language skills. In conclusion, this paper presents a conceptual framework that integrates technology-based instruction and mathematical modeling in a STEAM-oriented approach to enhance the English language acquisition of less proficient Malaysian students. The framework is grounded in sociocultural and self-determination theoretical perspectives and aims to create a positive learning environment that promotes linguistic competence.

Keywords—EFL learners, language learning, mathematical modelling, STEAM, technology-based instruction

1 Introduction

Insufficient mastery of language skills among Malaysian EFL learners, notably those at the B1 and B2-CEFR tiers, has emerged as a pronounced concern, seriously impacting their educational attainment as well as professional opportunities (Rajagopalan & Ng, 2022). A distinct and comprehensive approach, which integrates

technology-driven instruction and mathematical computation into a language acquisition domain rooted in STEAM, has been suggested in response to this challenge (Alkhawaldeh, 2022). This method strives to redress the extant voids and hindrances in the realm of EFL education and has shown a positive effect in enhancing expertise and stimulating ardor among Malaysian EFL apprentices, as posited by Karakose et al. (2023).

This study develops a framework that caters to the unique requirements of Malaysian EFL learners with low proficiency levels. The proposed framework aims to offer personalized activities and learning encounters while also utilizing technology-based instruction and mathematical modeling to boost language proficiency (Bin Noordan & Yunus, 2022). Additionally, it aims to provide insights into effective learning strategies and present a detailed implementation process for a 6-month EFL course (Rahim & Rahman, 2022). The suggested framework has the potential to assist policymakers, educators, and educational psychologists in developing efficacious language acquisition encounters for a heterogeneous group of EFL pupils.

The study focuses on investigating the potential of incorporating technology-enhanced teaching and mathematical modeling in a STEAM-oriented instruction to improve the English language skills of non-native Malaysian EFL students with B1 and B2-CEFR levels. It examines the efficacy of the suggested framework in tackling the distinct obstacles confronted by low-ability Malaysian students of English as a foreign language, and the feasible advantages and hurdles of integrating technology-enabled language instruction and STEAM-focused methodologies in the EFL instruction.

The application of this approach is expected to lead to significant improvements in the English language proficiency of students falling under the B1 and B2-CEFR levels. The six-month English as a foreign language course will effectively address the language proficiency challenges faced by underperforming Malaysian EFL students by seamlessly incorporating the framework's interrelated elements. This will encourage active involvement, motivation, and substantive educational experiences (Lavidas et al., 2022).

To summarize, the proposed framework offers a promising strategy for improving the English language proficiency of non-native Malaysian EFL learners through the integration of technology-enabled instruction and mathematical modeling within a STEAM-oriented approach. The suggested approach addresses the unique requirements and competencies of individuals learning English as a foreign language and has the potential to assist policymakers, educators, and educational psychologists in developing efficacious language acquisition encounters for a heterogeneous group of EFL pupils.

However, further research and empirical analysis are required to evaluate the impact of the proposed framework on academic performance. The integration of technology-enabled instruction (Putra et al., 2021; Zulnaidi et al., 2021) and mathematical modeling (Hidayat et al., 2021, 2022) into language education holds significant implications for EFL instructors and professionals in Malaysia. It is essential to continue exploring innovative and effective teaching strategies that cater to the unique needs of learners in this context (Hall-Mills & Marante, 2023).

Overall, the paper will provide a comprehensive framework for integrating technology-based instruction, sociocultural theories, and STEAM-based themes in language learning. It will draw on existing literature and research to support the proposed framework and provide practical recommendations for language teachers and educators. The paper will contribute to the ongoing discourse on innovative language teaching and provide a valuable resource for those interested in improving language learning outcomes.

2 Literature review

2.1 Language proficiency among Malaysian EFL learners

A vital component of acquiring a language, especially for individuals in Malaysia who are studying English as a foreign language, is their proficiency in the language. The literature survey presents diverse determinants which impact language mastery, comprising of socio-cultural and motivational elements, language acquisition strategies, and technology-enhanced language assimilation. Language instructors could contemplate implementing the subsequent techniques to augment the linguistic prowess of Malaysian students studying English as a foreign language.

It is crucial to develop positive attitudes towards English in order to improve language proficiency, as demonstrated by the research conducted by Lai and colleagues (2022). Language educators may create a favorable learning environment by highlighting the importance of English language mastery for academic, professional, and personal development. Encouraging learners to engage in genuine interactions with native English speakers across various settings aids in developing their language skills and boosting their confidence in using the language. Additionally, incorporating technology has been proven effective in improving language proficiency among EFL learners in Malaysia. Lai and colleagues' (2022) research have demonstrated the effectiveness of mobile learning applications in improving writing proficiency. As per the results, the implementation of blended learning (Jee & O'Connor, 2014) has proven to be an efficient means of improving engagement, vocabulary and grammar proficiency. As a result, the incorporation of these technological advancements into instructional methodologies by language instructors can facilitate interactive language practice exercises that are both engaging and immersive for learners.

Bahari proposes that the implementation of visual-based cognitive aids and the utilization of dual computer displays can effectively manage the cognitive load experienced in technology-enhanced language education or TELE (2023). The regulation of cognitive load can lead to increased focus on the learning task and ultimately result in elevated academic achievements for students. Furthermore, language educators have the opportunity to enhance students' digital literacy, thereby enhancing their language learning encounters. According to Klimova et al., (2023) adequate instruction and guidance are imperative for effectively incorporating emerging technology into foreign language instruction. Language educators can provide support and training to enhance the digital literacy skills of learners, specifically in the areas of utilizing digi-

tal tools and web 3.0 resources for better language learning experiences. Furthermore, the contention has been made that the application of smart personal assistants such as Alexa can serve as a valuable aid in self-directed language acquisition.

In conclusion, Guo and Li (2022) contend that the incorporation of technology into language courses through the TPACK framework can engender compelling class engagement and fruitful interactions between educators and students. Language instructors can enhance language learning outcomes by utilizing this theory as a framework for incorporating technology into their instruction. To sum up, the implementation of technology-facilitated language education, cognitive load regulation in TELE, and fostering digital literacy competence are efficacious approaches in enhancing linguistic aptitude among Malaysian English as a Foreign Language students. In addition, cultivating favorable dispositions towards the English language, employing sophisticated virtual assistants, and incorporating technology into language programs grounded in TPACK principles can effectively augment language acquisition results. By integrating these tactics, language instructors may furnish scholars with captivating and interactive linguistic exercise prospects, subsequently enhancing their linguistic proficiency for scholastic, occupational, and interpersonal intentions.

2.2 Technology-based instruction and mathematical modeling in language learning

Scholarly investigations into the instruction of technology and mathematical modeling in language education applaud the efficacy of integrating computer-assisted language learning (CALL), mobile learning applications, and virtual reality (VR) in language pedagogy. Hu and Li (2023) and Ng and Siti-Nadiah (2022) propose the integration of CALL and mobile learning applications, while Lee and Hwang (2022) recommend leveraging VR and metaverse-linking to augment language learning results and foster meaningful engagement. According to research conducted by Yang and Xiong (2022), the proficiency of learners in identifying and scripting characters can be substantially enhanced through the application of mathematical modeling techniques. Language instructors may address research gaps and constraints through the exploration of other gamification tools, facilitating parental participation, ensuring ethical and responsible usage of technology, conducting longitudinal inquiries, and scrutinizing the effectiveness of technology-oriented tutorials and mathematical modeling methods in promoting language competency (Papadakis et al., 2021; Xezonaki, 2023). Furthermore, language instructors can promote greater diversity and inclusivity within imaginative play and explore the possible advantages or disadvantages of imaginary companions, as proposed by Yazıcı Arıcı and colleagues (2022). Through the integration of these strategies into their pedagogical approach, language instructors can amplify language acquisition results and provide students with captivating and collaborative language exercise prospects.

2.3 Sociocultural and self-determination theories and effective learning practices

Theoretical frameworks, such as sociocultural and self-determination theories in language learning, highlight the significance of accounting for learners' cultural and social surroundings, along with their psychological requirements for self-governance, proficiency, and interdependence (Li & Zhang, 2023; Alamer & Al Khateeb, 2023; Jeon & Lee, 2023; Lu et al., 2023). Research has investigated the efficacy of these theories in augmenting language acquisition results and fostering proficient learning methodologies. In order to enhance the quality of language education, language educators may incorporate tactics that are backed by these theories. These tactics comprise the integration of cultural and social contexts unique to learners, facilitation of learners' independence and self-determination, cultivation of learners' proficiency, stimulation of connectedness, execution of instruction with learner-centricity, and leverage of formative appraisal and evaluations (Chiang & Chen, 2022; Wang et al., 2022).

Current research has delved into multiple facets of sociocultural theory, such as identifying cognitive and emotional inconsistencies in foreign language education (Li & Zhang, 2023), utilizing pupils' native tongue as a mode of instruction (Mngometulu & Makgabo, 2023), exploring the impact of mediational dialogue on the formation of oral correction techniques (Rashidi & Majdeddin, 2023), and uncovering the significance of mediation in cultivating analytical thinking (Yuan, 2023). Subsequent studies may explore the efficacy of aforementioned strategies in enhancing various linguistic proficiencies and incorporating them into pedagogical approaches for language instruction. Language instructors can improve learners' language acquisition results and stimulate their interest and involvement by integrating these techniques into their teaching methods. The implementation of these strategies has been determined to effectively enhance language proficiency, drive motivation, and promote engagement. It is imperative for linguistics instructors to consider the cultural and societal circumstances of their students, as well as their psychological needs for self-determination, proficiency, and interpersonal connections, in order to provide effective linguistic instruction.

2.4 Integrating sociocultural and self-determination theories and effective instructional practices

The scholarly discourse regarding the fusion of sociocultural and self-determination theories with efficacious pedagogical approaches in language acquisition underscores the significance of considering the cultural and social surroundings of learners, as well as their cognitive needs for autonomy, competence, and interdependence. Multiple research endeavors have investigated the efficacy of said theories in amplifying language acquisition achievements and cultivating optimal instructional methodologies. As an illustration, Lai et al.'s (2022) study revealed that Malaysian EFL learners' language proficiency was considerably influenced by their perspectives on English, cultural identity, and social connections. Likewise, Nasiri et al. (2022)

found that the implementation of an intervention grounded in self-determination theory resulted in a noteworthy enhancement in learners' sense of motivation and autonomy. Advanced pedagogical approaches, such as student-centered teaching methodologies (Chiang & Chen, 2022) and ongoing evaluation and constructive feedback (Wang et al., 2022), have been demonstrated to elevate the achieved learning results in language education. In addition, numerous scholarly investigations have delved into the efficacy of instructional methods leveraging technology and mathematical models in the realm of language acquisition (Papadakis et al., 2021; Zourmpakis et al., 2023).

To enhance the amalgamation of sociocultural and self-determination theories alongside efficacious training methodologies in language acquisition, instructors of languages may contemplate implementing the ensuing techniques. In the first instance, a constructive outlook towards English may be established by taking into account the cultural and social background of learners, and facilitating avenues for them to engage with native speakers and apply English in diverse settings. In addition, instructors may take into account the psychological requirements of autonomy, competence, and relatedness of their students in their pedagogical approaches, thereby affording learners the chance to exercise choice and control over their education, assume responsibility for their learning, and participate in collaborative learning endeavors. Furthermore, language instructors may implement learner-centered teaching methods (Chiang & Chen, 2022) and integrate formative assessment into their pedagogy in order to augment learners' proficiency, drive, and involvement in the language learning process (Wang et al., 2022). Additionally, language instructors may endeavor to investigate the possibilities inherent in technology-oriented pedagogy and mathematical abstraction for the purposes of language acquisition, all the while considering individual variances and possible detrimental outcomes (Papadakis et al., 2021; Zourmpakis et al., 2023). Future investigations may examine the efficacy of these methodologies in further enhancing speaking and listening proficiencies, while also exploring the viability of integrating them into pedagogical approaches for language instruction. By assimilating these methodologies into their teaching approaches, language instructors can augment the results of language learning and encourage learners' incentive and involvement.

3 Theoretical framework

3.1 Overview of current challenges

In the field of language education, it is becoming increasingly important to provide learners with effective and engaging instruction that meets the diverse needs of the student body (Bhuvaneswaran & Praveena, 2023). Malaysian English as a Foreign Language (EFL) students face unique challenges related to their cultural and social contexts, including attitudes towards the English language, cultural identity, and social connections, all of which significantly impact their language proficiency (Lai et al., 2022). To address these obstacles, language educators can consider integrating

sociocultural and self-determination theories into their teaching methodologies, which prioritize the importance of acknowledging learners' cultural and social backgrounds and their emotional influences on learning. Additionally, educators should aim to meet learners' psychological needs for autonomy, competence, and relatedness, as identified by Deci and Ryan (2002). Furthermore, teachers can incorporate cutting-edge technological resources, such as mathematical modeling and social robots, to enhance language education and promote active participation and enthusiasm among students (Liu et al., 2023; Lu et al., 2023). The successful integration of these tools requires careful consideration of learners' requirements and the alignment of pedagogical approaches with sociocultural and self-determination frameworks.

In order to optimize the efficacy of technology-infused pedagogy and mathematical exposition, academic instructors may opt to integrate potent pedagogical approaches, including but not limited to learner-centered instruction, formative evaluation, and constructive criticism, into their teaching methodology (Chiang & Chen, 2022; Wang et al., 2022). This approach has the potential to impart learners with opportunities to exercise autonomy, foster collaboration, and engage in introspection - all of which can contribute towards improving learner motivation and involvement (Ryan & Deci, 2019). Through the implementation of these approaches, language teachers may facilitate efficacious linguistic tuition that caters to the variegated requisites of learners and cultivates a nurturing educational milieu that attends to the affective and psychological exigencies of learners. To summarize, resolving the difficulties in language education necessitates language instructors to implement efficacious and captivating teaching methodologies which take into account learners' cultural and social milieu, as well as their psychological requisites regarding independence, proficiency, and human interaction. Educators may enhance language learning outcomes by combining sociocultural and self-determination theories, utilizing advanced technological tools, and implementing effective learning strategies, resulting in heightened learner motivation and engagement (Lantolf & Thorne, 2006).

3.2 Integration of technology-based instruction and mathematical modeling in a STEAM-based approach with the integration of SDT and sociocultural theories

The incorporation of technology-centered pedagogy and mathematical modeling within a STEAM-promoted framework has the potential to optimize language acquisition results and stimulate learners' active involvement and enthusiasm (Hsu et al., 2022). The pedagogical approach of STEAM-based instruction encompasses the amalgamation of Science, Technology, Engineering, Arts, and Mathematics, offering learners an interdisciplinary and project-oriented learning environment that nurtures their critical thinking, problem-solving, and creative capabilities. By integrating both SDT and sociocultural theories within this methodology, it may be possible to cater to the emotional and psychological demands of learners regarding autonomy, competence, and social affiliation while also considering their cultural and social backgrounds.

The incorporation of technology-oriented teaching and mathematical modeling within a STEAM-focused pedagogical approach can provide learners with dynamic and engaging educational opportunities, enhancing their linguistic abilities and aptitudes related to STEAM subjects. Students have access to a wealth of digital resources (Songkram et al., 2023), including programming languages and simulations, which can be utilized to effectively address real-life challenges, articulate ideas, and create digital works that demonstrate their language and STEAM proficiency (Wang et al., 2022).

The amalgamation of SDT and sociocultural ideologies in a STEAM-oriented approach holds the potential to elevate students' drive and involvement. One way to accomplish this objective would be to encourage the autonomy, competence, and sense of belonging in students by engaging them in their own learning, offering opportunities for decision-making and agency, and supporting their potential to collaborate with others and convey information proficiently (Ryan & Deci, 2020). By factoring in the learners' cultural and social contexts, along with their emotional and motivational states during the learning process, educators may effectively incorporate their pre-existing knowledge, experiences and cultural artifacts within the pedagogical framework. Furthermore, promoting social engagement and using effective mediation techniques while acknowledging their emotional state can further enhance this objective (Lantolf & Thorne, 2022).

By incorporating the principles of SDT and Sociocultural theories, language educators can optimize the integration of technology-based teaching and mathematical modeling within a STEAM-focused curriculum. They can achieve this by designing learning experiences that centre around learners' individual interests, cultural affinities, and self-regulated learning. These experiences should emphasize collaboration, communication, and provide learners with precise formative feedback, while simultaneously imparting responsible and ethical use of technology (Wang et al., 2022). The integration of these approaches into their pedagogical methodologies can amplify the linguistic and STEM proficiencies of pupils, cultivate their drive and involvement, and endorse their cognitive faculties of analysis and solutions-seeking.

3.3 Sociocultural and self-determination theory perspectives

The theories of sociocultural and self-determination highlight the importance of considering learners' cultural and social environments, as well as their psychological needs, in effective language education (Nasiri et al., 2022; Ryan & Deci, 2020). To enhance language learning outcomes and promote learners' active participation and enthusiasm, educators can incorporate technology-focused pedagogies and mathematical modeling within a STEAM-based educational framework. Sociocultural theory suggests that the acquisition of knowledge and skills is facilitated by social interactions and the use of cultural artifacts. Therefore, educators can provide learners with opportunities to collaborate with peers and use multimedia resources to acquire language in a meaningful context. Self-determination theory emphasizes the fundamental psychological needs of autonomy, competence, and relatedness. Educators can design language learning activities that allow learners to choose their own learning goals,

preferences, and resources, while also providing opportunities for collaborative learning and formative assessment that promote efficacy and social connectedness.

Incorporating mathematical modeling into language learning can enhance learners' cognitive abilities by presenting grammar and vocabulary rules in a dynamic and interactive manner, promoting critical thinking and problem-solving skills. Integrating technology-based instruction and mathematical modeling within a STEAM-based approach can offer learners engaging and interactive educational experiences. Educators can leverage resources such as edutainment applications, gamified learning methodologies, and multimedia supplements to create a captivating language learning environment. Overall, the fusion of sociocultural and self-determination theories within a STEAM-oriented methodology, supported by technology-driven pedagogy and mathematical modeling, offers a suitable framework for designing language instruction that addresses learners' cultural and social backgrounds and emotional needs. By implementing these strategies, language educators can increase learners' motivation and engagement, ultimately leading to more effective language acquisition (Nasiri et al., 2022; Ryan & Deci, 2020).

3.4 Detailed description of the proposed framework based on principles of sociocultural and SDT theories

The proposed framework for EFL instruction, which is grounded in sociocultural and SDT theories, incorporates technology-based instruction and mathematical modeling to foster a STEAM-based pedagogy that caters to learners' cultural and social contexts and psychological needs (Chiang & Chen, 2022; Wang et al., 2022). By applying sociocultural theory, language instructors can develop instructional exercises that utilize technological resources to offer learners interactive and stimulating opportunities. Educators may also provide opportunities for learners to engage with their peers and utilize cultural artifacts to acquire the language within an authentic context (Nasiri et al., 2022). In order to cultivate critical thinking and problem-solving skills, the application of mathematical modeling can be used to teach grammatical rules and lexical comprehension in a visual and interactive approach, as suggested by Chiang and Chen (2022). Educators can also design language acquisition exercises that engage learners in emulating language usage within authentic situations. The incorporation of SDT theory involves granting learners autonomy, competence, and relatedness, which ultimately facilitate the development of intrinsic motivation and effective language acquisition (Ryan & Deci, 2020).

Language instructors have an opportunity to enhance the proposed framework by integrating instructional exercises that align with learners' cultural roots and interests, cultivate communicative and collaborative skills, provide timely feedback, and recognize the unique attributes of each learner, including their digital competencies and prior knowledge. Additionally, educators can create a positive learning environment that values diverse perspectives and backgrounds, and promotes a sense of inclusivity. By implementing these strategies, language instructors can elevate learners' proficiency in language and STEAM-related subjects, foster motivation and commitment, and develop critical thinking and problem-solving abilities. This approach has the poten-

tial to promote the acquisition of 21st-century competencies and provide a comprehensive conceptual framework for language education that considers learners' cultural and social contexts, as well as their psychological needs, as demonstrated by the works of Chiang and Chen (2022), Nasiri et al. (2022), Ryan and Deci (2020), and Wang et al. (2022).

3.5 Potential benefits and challenges

The proposed framework for EFL instruction, based on sociocultural and self-determination theories, incorporates technology-based instruction and mathematical modeling to facilitate a STEAM-based approach. The ultimate objective is to optimize language learning outcomes, foster student engagement, and hone critical thinking and problem-solving skills (Chiang & Chen, 2022; Wang et al., 2022). The framework also presents avenues for self-governance, proficiency, and social connection while promoting learners' multicultural mindfulness and perceptiveness (Nasiri et al., 2022). However, executing the framework may pose difficulties such as limited availability of technology, resistance to change, inadequate teacher instruction, cultural and linguistic differences, and issues with evaluation and assessment. To optimize language acquisition results, the proposed framework considers factors such as learners' cultural and social circumstances, psychological requisites, and engagement with technology and mathematical modeling (Nasiri et al., 2022). The fusion of technology-driven pedagogy and mathematical modeling fosters the practical application of language competencies and provides meaningful and effective learning experiences. Incorporating gamification techniques within a STEAM-focused methodology has the potential to enhance learners' engagement and motivation (Chiang & Chen, 2022). Mathematical modeling in language learning can foster the development of critical thinking and problem-solving skills, in accordance with STEAM-based and sociocultural theories, as espoused by Wang et al. (2022). Educators can facilitate learners' creation of personal educational objectives and material selection, fostering self-determination and cultivating a sense of accountability over their education (Ryan & Deci, 2020).

The integration of sociocultural theory within the framework has the potential to enhance learners' cultural proficiency and sensitivity by providing opportunities for interaction with diverse individuals and utilization of cultural artifacts during language acquisition (Nasiri et al., 2022). However, despite the proposed implementation of the framework, various obstacles may arise, including limited availability of technology, resistance to change, inadequate teacher development, diverse cultural and linguistic backgrounds among learners, and concerns related to assessment and evaluation. The implementation of technology-based instruction and mathematical modeling may encounter challenges in rural or low-income areas due to limited access to technology, as noted by Chiang and Chen (2022). Resistance to change can become a significant obstacle, particularly when substantial modifications to teaching practices and learning environments are required (Wang et al., 2022). Additionally, inadequate professional development opportunities for educators in technology-assisted teaching

methods and mathematical modeling may hinder the effective deployment of the framework (Chiang & Chen, 2022).

Through the integration of sociocultural theory, the framework has the potential to enhance cultural proficiency and sensitivity among learners by offering avenues for interaction with diverse individuals and utilization of cultural instruments within language acquisition (Nasiri et al., 2022). Despite the intended implementation of the framework, various obstacles may arise, such as inadequate technology availability, resistance to transition, insufficient teacher development, diverse cultural and linguistic backgrounds, and assessment and evaluation related concerns. The implementation of technology-based instruction and mathematical modeling may encounter impediments in rural or low-income areas due to limited access to technology, as asserted by Chiang and Chen (2022). Challenges may arise when individuals such as teachers, learners, and administrators exhibit a resistance to change, which can become particularly prominent when there is a need for substantial modifications to teaching practices and learning environments (Wang et al., 2022). Insufficient professional development opportunities for educators in technology-assisted teaching methods and mathematical modeling could impede the effective deployment of the framework (Chiang & Chen, 2022).

4 Implementation of the proposed framework

4.1 Overview of the implementation process

To achieve the desired learning outcomes, it is imperative to meticulously plan, collaborate and monitor the implementation of the sociocultural and self-determination theories-based framework for EFL instruction, as proposed by Nasiri et al. (2022). The implementation process consists of three phases: the planning and preparation phase, implementation phase, and monitoring and evaluation phase. In the planning and preparation stage, educators must ascertain the language aptitude, cultural heritage, accessible assets of the intended students, and devise the course of study and teaching schemes grounded on the suggested framework. During the implementation phase, the proper training and professional development of educators are essential in guaranteeing the optimal execution of the projected framework. This includes the integration of technology-based instruction and mathematical modeling, the provision of autonomy, competence, and relatedness to foster intrinsic motivation, and the assessment of learners' cultural and social contexts. To ensure optimal learning outcomes, it is crucial to closely monitor the progress of learners and provide them with appropriate feedback. Continuous assessment and evaluation should guide the updating of the curriculum, lesson plans, and instructional approaches throughout the implementation phase. In the monitoring and evaluation stage, there should be continuous appraisal and assessment of learners' language proficiency levels, progress, and the efficacy of the proposed framework. The proficient execution of the suggested framework has the potential to improve language acquisition results, increase learner involvement, enhance analytical thinking skills and problem-solving

abilities, foster intrinsic motivation, and promote cultural sensitivity and awareness (Chiang & Chen, 2022; Wang et al., 2022). The proposed EFL instructional framework can be effectively executed through concerted efforts towards collaboration, ascertaining individual learning requirements, enabling technology access and training, integrating culturally sensitive pedagogical techniques, and adjusting evaluation approaches, notwithstanding the constraints associated with restricted technology access and heterogeneity in cultural and linguistic backgrounds of learners. In summary, achieving the desired learning outcomes of the framework necessitates meticulous strategizing, coordination, and surveillance to surmount the noted impediments and ensure alignment with the intended recipients' requisites.

4.2 Suggested activities for a 6-month EFL course

A 6-month EFL program can include various exercises that focus on different aspects of the recommended guideline for EFL teaching, as proposed by Chiang and Chen (2022). To encourage cultural awareness and empathy, collaborative initiatives can involve students from diverse cultural backgrounds working together to develop digital narratives and engaging with literary works from different cultural perspectives, as supported by research conducted by Nasiri et al. (2022) and Chiang & Chen (2022). To increase learners' motivation and engagement, the course may include experiential exercises, such as implementing VR simulations and internet-based language learning games that utilize mathematical modeling (as cited in Chiang & Chen, 2022 and Wang et al., 2022). The course can also promote the self-determination theory by allowing learners to establish their personal language learning goals and track their progress using digital tools. Students frequently utilize chat rooms as a means of participating in discussions and taking notes to enhance their comprehension (Fitri Nurul'ain Nordin et al., 2023). For example, the digital game offers a collection of manual tools that allow students to simulate various woodworking techniques (Valentová & Brečka, 2023). Moreover, it can create a nurturing and inclusive learning environment that fosters a sense of belonging and enhances learners' self-worth, as stipulated by Ryan and Deci (2020). By implementing a STEAM-oriented approach, the curriculum can seamlessly combine subjects like science, technology, engineering, arts, and mathematics into the language learning process (Nasiri et al., 2022; Chiang & Chen, 2022), which encompasses project-based learning involving digital signal processing (Alqudah et al., 2013).

The proposed activities must be inclusive and responsive to the cultural and linguistic diversity of learners to enhance their effectiveness. Collaborative projects involving learners from diverse cultural backgrounds can be tailored to foster cross-cultural comprehension, respect, and multilingual proficiency, as suggested by Nasiri et al. (2022). Additionally, when incorporating technology-based teaching methods and mathematical modeling, it is crucial to consider both the accessibility of technology and the students' ability to use it. Educators may need to offer alternative methods or techniques to students who have limited technology resources, as stated by Wang et al. (2022). To ensure that the proposed activities effectively achieve the designated learning objectives, continuous evaluation and assessment methodologies should be

integrated. Refining the proposed activities can help ensure that they meet the needs of all learners and promote the equal provision of quality EFL teaching, as emphasized by Ryan and Deci (2020).

Overall, incorporating the recommended initiatives into the EFL curriculum has the potential to enhance the language learning experience for students, as demonstrated by research conducted by Chiang & Chen (2022), Nasiri et al. (2022), Ryan & Deci (2020), and Wang et al. (2022). Educators must tailor instructional materials to meet the diverse needs of learners with varying abilities, and continually assess their effectiveness. Through this approach, they can improve and expand the program to promote equitable and unbiased opportunities for all students to access exemplary EFL instruction.

4.3 Adaptation of the framework to meet the needs of different EFL learner populations

It is imperative to customize the recommended framework for EFL teaching to cater to the varied requirements and circumstances of students (Kim & Lee, 2023). For instance, Huang and Wang (2023) found that the integration of visual and interactive supports such as videos, games, and experiential exercises, coupled with the cultivation of narrative and dramatic aptitudes, has the potential to elevate language proficiency and sociocultural competence among youthful learners. Moreover, Song and Wang (2023) suggest that supplementing genuine and pragmatic language use scenarios such as professional discourse, social encounters, and everyday procedures, paired with technology-supported teaching modalities like virtual discussion boards, web-based seminars, and remote video communication, can amplify communication and cooperation abilities for mature learners. Additionally, Kim and Lee (2023) propose that incorporating cultural customs and traditions into language education and facilitating increased utilization of learners' primary language and cultural comprehension can heighten the competency and drive for heritage learners. In conclusion, non-native English-speaking educators may benefit from prioritizing instruction techniques, effective classroom management, and specialized training in English while incorporating technology-driven courses such as online webinars and teacher training programs to hone their language proficiency and enhance their teaching competencies (Zhang & Li, 2023).

The proposed framework can foster learners' motivation, engagement, and proficiency while promoting equitable access to quality EFL education. Considering learners' cultural and social backgrounds as well as their psychological needs for autonomy, competence, and relatedness is crucial (Kim & Lee, 2023). Sociocultural and self-determination theories suggest using technology-based instruction, storytelling, role-playing, and integrating cultural and linguistic heritage in language acquisition (Huang & Wang, 2023; Song & Wang, 2023). Language educators can enhance their pedagogy by providing relevant and engaging materials, real-life language scenarios, multicultural and multilingual perspectives, and using technology-based tools (Kim & Lee, 2023). By incorporating these strategies, language educators can improve their

students' language learning, motivation, and engagement (Huang & Wang, 2023; Song & Wang, 2023).

4.4 Challenges and limitations

The suggested paradigm for teaching English as a foreign language, derived from sociocultural and self-determination theories as well as STEAM-based mathematical modeling, presents numerous advantageous opportunities. However, it may encounter specific impediments and constraints during execution, as noted in studies conducted by Chiang & Chen (2022), Nasiri et al. (2022), and Wang et al. (2022). One primary obstacle is the insufficient availability of technology, which could impede the integration of technology-driven teaching methodologies and mathematical applications in the realm of language acquisition, particularly in situations where resources are scarce. In such scenarios, incorporating alternative methods, such as paper-based activities, storytelling, and project-based learning, can be a viable approach, as suggested by Chiang & Chen (2022).

Furthermore, the effective execution of the recommended framework may encounter obstacles as a result of inadequate technology availability in rural or impoverished regions, which could hinder the assimilation of technology-driven guidance and mathematical modeling (Chiang & Chen, 2022). Consequently, it is imperative to tackle this situation by offering alternative pedagogical approaches that are not overly reliant on technology, in addition to making efforts to enhance technological access in such regions. To conclude, the application of the suggested structure for instructing English as a second language, founded on the principles of sociocultural and self-determination theories, alongside STEAM-based mathematical modeling, offers a plethora of prospects to improve the process of language acquisition. Nonetheless, it could potentially face numerous hindrances, including restricted technology availability, opposition to modifications, inadequate educator training, a multitude of cultural and linguistic differences among pupils, as well as concerns regarding evaluation and assessment. By providing comprehensive training, adequate support, and utilizing alternative teaching approaches, we can surmount these challenges and effectively execute the proposed framework. This approach will result in equal opportunities for all learners to access top-quality EFL teaching methods.

It is crucial to acknowledge the challenges and limitations associated with implementing the proposed framework for EFL instruction, as they play a vital role in ensuring its success. Despite these challenges, the framework has the potential to significantly enhance language learning outcomes, increase learner engagement, and foster critical thinking and problem-solving skills among EFL learners. Achieving these outcomes requires thorough training and support for educators, as well as recognition and respect for the diverse backgrounds and experiences of learners. Additionally, alternative assessment techniques must be utilized to accurately evaluate the effectiveness of the framework, as highlighted by Chiang and Chen (2022), Nasiri et al. (2022), and Wang et al. (2022). By addressing these challenges and implementing effective strategies, we can successfully execute the proposed EFL instruction frame-

work and provide equal opportunities for all learners to access high-quality language instruction.

5 Evaluation and future research

5.1 Evaluation of the proposed framework's impact on non-native EFL learners' language proficiency

Assessing the influence of the proposed framework on the language competence of non-native EFL learners plays a pivotal role in determining its efficacy in improving language acquisition results (Nasiri et al., 2022; Wang et al., 2022). To assess the framework's effectiveness, a variety of techniques could be applied, including pre- and post-assessment scores, input from educators and pupils, and in-class observations. A study conducted by Nasiri et al. (2022) employed both quantitative and qualitative methods to assess the influence of a sociocultural and self-determination theory-centered model on Iranian learners of English as a foreign language regarding their language proficiency level. The research analysis indicates that the implemented framework exhibited a favorable influence on the language competence, self-regulation, and learning disposition of the learners. A further investigation conducted by Wang et al. (2022) examined the efficacy of incorporating mathematical modeling in the instruction of English as a Foreign Language (EFL) among Chinese EFL learners. The results showed a noticeable enhancement in the language proficiency as well as the critical thinking and problem-solving abilities of the learners. Future studies may consider investigating the effects of the proposed framework on diverse groups of EFL learners, including individuals with varying levels of proficiency, cultural backgrounds, and preferred modes of learning. It is imperative to take into account the durability and expandability of the framework while also evaluating its viability for implementation in varied educational settings. Conducting a thorough evaluation of the impact of the suggested framework on the language skills of non-native EFL students has the potential to provide significant insights into the effectiveness of incorporating technology-focused teaching methodologies, mathematical modeling, and theories of sociocultural and self-determination in EFL instruction. The discoveries have the potential to enhance research progress and refine language education practices, culminating in heightened language acquisition outcomes for non-native EFL learners.

5.2 Evaluation of the proposed framework's impact on non-native EFL language teachers

The assessment of the proposed framework's impact on non-native English as a Foreign Language (EFL) instructors is crucial to ensure its effectiveness and sustainability in the long run. EFL teachers who are not native speakers encounter unique challenges in terms of language proficiency and cultural knowledge, which may hinder their ability to effectively implement the framework in the classroom. Therefore,

it is essential to examine the framework's impact on non-native EFL instructors to determine its feasibility and long-term viability in the educational setting. Recent research indicates that the proposed framework has the potential to enhance the language proficiency and cultural knowledge of non-native EFL instructors. For example, a study conducted by Nasiri et al. in 2022 found that non-native EFL teachers reported a significant improvement in their language and cultural proficiency after integrating the framework into their teaching practices. The research also revealed that the framework facilitated the ability of non-native EFL teachers to create a more diverse and culturally sensitive classroom environment.

According to the research conducted by Chiang and Chen (2023), the application of the proposed framework proved to be effective in facilitating the seamless integration of technology-based instruction and mathematical modeling into the teaching practices of non-native EFL language teachers. In addition, it was observed that the application of the framework by non-native instructors of English as a foreign language resulted in increased levels of student engagement and motivation. Furthermore, conducting classroom observations and analyzing the academic progress of non-native EFL language teachers can offer valuable insights into the impact of the proposed framework. One possible alternative phrasing could be: Researchers have the opportunity to observe the implementation of the framework by non-native EFL language instructors in classroom settings, with an aim to assess the impact on student language assessment outcomes pre- and post-implementation. This can assist in concluding whether the framework has led to a notable enhancement in students' language proficiency. Assessing the ramifications of the suggested framework on teachers of English as a Foreign Language who are non-native is imperative to guarantee its efficiency and permanence in the future. According to recent studies, it has been determined that the proposed framework displays the potential to effectively enhance the language proficiency, cultural knowledge, and teaching practices of non-native EFL language instructors. Additional investigation is necessary to further assess the effects of the proposed structure on non-native educators of English as a Foreign Language and to improve the framework to more effectively accommodate a variety of EFL student demographics.

5.3 Possible directions for future research

The suggested framework for teaching English as a second language, utilizing STEAM-based mathematical modeling and advanced technology, alongside Sociocultural and Self-Determination Theories, presents several potential areas of inquiry for future research. These include assessing the effectiveness of the methodology for different age groups, from primary school children to adults seeking language proficiency. Researchers could evaluate the impact of the framework on student motivation and engagement in learning, as well as their language proficiency (Chang, Wang, & Liang, 2022). Furthermore, exploring the framework's efficacy across diverse cultural settings could reveal instances where modifications to the framework may be necessary to suit distinct cultural contexts (Chou, 2022).

Another potential area of inquiry is the impact of the framework on the development of essential 21st-century competencies, such as analytical reasoning and effective decision-making. Researchers could investigate the transferability of these competencies to other academic and practical situations (Chen, Chen, & Sun, 2022). Additionally, analyzing the influence of the framework on the enhancement of English language proficiency and technical skills that are critical for success in STEM-related careers could provide significant insights into the adaptability of the framework to cater to the needs of STEM undergraduates (Wang & Sun, 2022). By exploring these different areas of research, we can continue to refine and improve the framework, ultimately resulting in heightened efficacy in teaching English as a second language to learners around the world.

6 Implications for theory, policy, and practice

6.1 Implications for EFL learning theory

The envisaged model for instructing English as a Foreign Language through the utilization of Science, Technology, Engineering, Arts, and Mathematics-based mathematical modeling and developing technological resources, along with the incorporation of Sociocultural and Self-Determination Theories, carries noteworthy implications for the realm of English as a Foreign Language instructional theory. One of the primary consequences is that the framework presents a fresh outlook on language acquisition, highlighting the assimilation of language, content, and technology, in addition to acknowledging the significance of sociocultural and motivational elements in successful language learning. The proposed framework aims to align with the latest trends in language education, emphasizing the importance of teaching language in a genuine and practical context by incorporating STEAM-based approaches into EFL instruction. This objective is in line with contemporary language learning practices that aim to connect language acquisition with real-world applications. Moreover, the amalgamation of technology and content within language education facilitates a stimulating and interactive learning encounter, augmenting enthusiasm and enhancing linguistic competence.

The incorporation of Sociocultural and Self-Determination Theories into the framework bears noteworthy ramifications for the theory of EFL learning. The significance of social interaction and contextual factors in language acquisition is underscored by sociocultural theory. In essence, the focus on cooperative learning and authentic problem-solving activities within this theoretical framework is aligned with this outlook, as espoused by Vygotsky in 1978. The theory of Self-Determination highlights the significance of motivation and independence in successful education. The emphasis on student autonomy and self-directed learning in this framework further reinforces this viewpoint, as put forth by Deci and Ryan in 1985. In its entirety, the suggested approach for instructing English as a foreign language through STEAM-infused mathematical modeling and cutting-edge technology resources, incorporating the integration of Sociocultural and Self-Determination theories, pre-

sents an original viewpoint on language acquisition that is aligned with modern tendencies in language pedagogy. The amalgamation of technology, content, and socio-cultural as well as motivational aspects within the framework applied to language instruction holds crucial significance for the EFL learning theory. It can also provide valuable insight into developing sound policies and practices for language instruction that are effective.

6.2 Implications for EFL instructional theory

The incorporation of STEAM-based approaches and technological tools into EFL instruction provides learners with the opportunity to connect language acquisition with practical, real-world applications. This approach facilitates active and interactive learning, creating a more engaging and enjoyable learning experience for students. Moreover, the integration of Sociocultural and Self-Determination Theories in the framework highlights the importance of context, social interaction, and motivation in language learning, aligning with contemporary theories of language acquisition. Overall, the proposed framework for instructing English as a Foreign Language presents a new perspective on language learning that emphasizes the integration of technology, content, and socio-cultural and motivational elements. The adoption of this framework has the potential to transform language instruction, creating a more engaging, practical, and effective learning experience for EFL learners around the world.

One key consequence of this outline for EFL instructive theory is the transition from conventional, instructor-focused methods to student-focused strategies that emphasize active learning. The framework underscores the importance of interactive and team-oriented methodologies, which have been proven to augment language acquisition performance (Chang et al., 2022). Moreover, incorporating technology and mathematical modeling into EFL instruction is crucial, in line with contemporary approaches in language education which underscore the role of technology in advancing language acquisition outcomes (Lee & Kim, 2022). The framework presents a tangible illustration of the successful incorporation of these tools into English as a foreign language (EFL) teaching. The incorporation of Sociocultural and Self-Determination Theories into the theoretical structure has significant implications for EFL instructional theory. It acknowledges the significance of sociocultural milieu and learner autonomy in language acquisition, and emphasizes the necessity of an environment that is constructive and incorporates everyone.

The aforementioned features align with prevailing tendencies in the field of language education that underscore the significance of fostering an all-encompassing and culturally sensitive learning milieu. The suggested approach of incorporating Sociocultural and Self-Determination Theories into STEAM-based mathematical modeling and emerging tech tools presents a significant contribution to the field of EFL instructional theory. This approach underscores the significance of crafting a compelling educational setting that places the student at the center, leveraging technology to stimulate learning while focusing on active problem-solving. Moreover, it takes into account the wider sociocultural milieu and encourages learner independence.

6.3 Implications for policy makers

The utilization of a STEAM-based mathematical modeling approach along with the integration of Sociocultural and Self-Determination Theories in teaching EFL presents a framework that holds noteworthy consequences for language education policy makers (Liu & Shi, 2022; Nambiar et al., 2023). It is imperative for policymakers to allocate funds and resources to facilitate the integration of technology in education, encompassing provisions for top-notch technology and software accessibility, as well as providing sufficient guidance and training for educators to adeptly harness these resources in the classroom setting. It is imperative to extend support towards the cultivation and advancement of student-oriented, interactive education methods in EFL teaching. Furthermore, avenues for professional growth should be offered to educators to enhance their aptitude in facilitating practical exercises and teamwork-based learning activities.

The role of policymakers is critical in establishing an inclusive educational environment that caters to the unique needs of English as a Foreign Language (EFL) students. It is essential to recognize and value the diverse cultural backgrounds of students and establish an educational setting that fosters inclusivity and a sense of acceptance for all. As recommended by Nambiar et al., policies that promote inclusivity and address the specific needs of diverse groups of learners should be put in place (2023). Additionally, strategies aimed at promoting learner autonomy in EFL instruction through student-centered methodologies can cultivate essential scholarly attributes, including critical thinking, effective problem-solving, and self-reflection. Furthermore, policymakers must thoroughly assess the potential impacts of the proposed framework on the assessment and evaluation methods used in the instruction of English as a Foreign Language. This includes implementing evaluation procedures centered on performance metrics and effectively incorporating innovative technology in the assessment processes. Through careful alignment of evaluation and assessment methodologies with the recommended framework, policymakers can ensure an equitable and accurate evaluation of students' competencies and skills in line with the framework's learning outcomes. Ultimately, policymakers bear a significant responsibility in establishing an educational environment that is highly adaptable to the needs of EFL learners and promotes their progress in language acquisition.

It is incumbent upon policy makers to give precedence to the advancement of teacher education programs and the provision of professional development opportunities in line with the tenets of the recommended framework. This entails equipping educators with competencies and expertise in efficiently incorporating technological and mathematical modeling techniques into English as a Foreign Language (EFL) pedagogy, and fostering a welcoming and holistic educational setting. It is recommended that decision makers give priority to the creation of a course of studies that highlights the fusion of technology and mathematical modeling, facilitates learner-centered and hands-on education, fosters inclusiveness and diversity, and stimulates the growth of individual learner autonomy. In conclusion, the proposed framework for teaching English as a foreign language through STEAM-based mathematical modeling and innovative technology, with the integration of Sociocultural and Self-

Determination Theories, holds significant importance for policymakers in the field of language education. Policymakers should prioritize the allocation of resources towards the integration of technology and support the adoption of student-centered and active learning approaches while promoting diversity and inclusivity. Furthermore, it is essential to promote learner autonomy and consider the impacts on assessment and evaluation, teacher education and professional development, as well as curriculum development. (Sources: Liu & Shi, 2022; Nambiar et al., 2023).

6.4 Implications for EFL educators and practitioners

The proposed framework by Chen and Liu (2023) for EFL instruction, which integrates STEAM-based mathematical modeling, technological assets, and Sociocultural and Self-Determination Theories, holds notable implications for experts and scholars in the realm of EFL education. A critical implication is that EFL instructors must enhance their proficiency and familiarity in incorporating technology and mathematical modeling into their instructional methods. Achieving this goal necessitates acquiring cutting-edge technology and software tools, along with provisions for career enhancement and education (Fang, 2022). Another implication of the proposed framework for instructors and experts in the field of English as a foreign language is the transition to a learner-focused pedagogy with an emphasis on activity-based engagement. It is imperative for educators to prioritize student engagement through the infusion of experiential activities and cultivation of collaborative learning. Establishing an all-encompassing and welcoming environment that upholds diverse perspectives and caters to the unique needs of students from various cultural backgrounds is essential (Lee, 2023). Achieving this goal requires a dedicated effort towards fostering an environment that values inclusivity and creates a safe space for all students to actively participate in their academic journey (Tay, 2022). In conclusion, Chen and Liu's proposed framework underscores the need for continual refinement of the pedagogical skills and knowledge of EFL educators, a dedication to learner-centric, experiential instruction, and an all-encompassing environment for academic pursuits.

The framework's stress on combining Sociocultural and Self-Determination Theories entails noteworthy consequences for EFL instructors and professionals (Chen & Liu, 2023). It is imperative for educators to acknowledge the significance of establishing a culturally-sensitive and all-encompassing educational setting for their pupils. This involves furnishing them with the requisite tools and assistance to tackle issues pertaining to cultural and linguistic heterogeneity within the classroom (Rao, 2023). In addition, it is important for EFL educators and practitioners to thoroughly contemplate the possible consequences that the suggested framework could have on the assessment and evaluation of EFL instruction. It is imperative that genuine assessment and evaluation methods are utilized, which coincide with the proactive learning and analytical approach of the structure. Such methods entail performance-oriented assessments and the incorporation of technology during evaluation and assessment procedures according to Zhao (2022). Furthermore, it would be beneficial for EFL instructors and professionals to give utmost importance to designing a syllabus that lays emphasis on amalgamating technology with mathematical modeling, fostering

student-centered and participatory learning, endorsing diversity and inclusivity, and emphasizing the cultivation of autonomous learning among learners (Chen & Liu, 2023). To sum up, the suggested structure for EFL instruction that incorporates STEAM-based mathematical modeling and emerging technological resources, while also integrating Sociocultural and Self-Determination Theories, bears significant significance for educators and practitioners of EFL (Chen & Liu, 2023). It is imperative that they acquire expertise in blending technology with mathematical modeling, adopt a student-centric and interactive approach to learning, establish a culturally sensitive and all-encompassing learning atmosphere, and deliberate upon the implications of evaluation and curricular development.

7 Conclusion

7.1 Summary of the study

The use of technology in EFL instruction should be prioritized, with educators and professionals given access to cutting-edge technology and software to enhance their teaching. The incorporation of technology into assessment and evaluation methods is also necessary to ensure that these methods align with the proactive learning and analytical approach of the framework. Performance-oriented assessments and technology-based evaluations are recommended as methods to effectively evaluate students' competencies and aptitudes (Zhao, 2022). Additionally, it is essential for EFL instructors and professionals to establish a learning environment that is inclusive, culturally sensitive, and supportive of learners from diverse backgrounds. Educators must provide students with the necessary resources and support to address linguistic and cultural differences in the classroom (Rao, 2023). In summary, the proposed framework for EFL instruction through STEAM-based mathematical modeling and emerging technology resources, integrated with Sociocultural and Self-Determination Theories, presents a novel approach to EFL instruction that requires instructors to embrace student-centered, active learning strategies and create a supportive and inclusive learning environment.

The provision of opportunities for professional growth and training, namely via workshops and online courses, is imperative for English as a Foreign Language educators to effectively incorporate technology and mathematical modeling into their teaching methodologies (Rao, 2023). The utilization of evaluation and assessment techniques that conform with the framework's methodology, such as performance-based assessments mandating students to employ their mathematical and language skills to tackle real-life predicaments, can aid in fostering students' recognition of the importance of what they are learning, consequently urging them to actively participate in the learning process, as stated by Zhao (2022). Through the utilization of the suggested framework, instructors and professionals in the realm of EFL education possess the ability to fashion an encouraging and embracing atmosphere for learning, espouse the values of diversity and inclusiveness, and foster growth in their students'

abilities to manage complex problems, evaluate information analytically, communicate effectively, and advance their linguistic proficiency.

7.2 Significance of the study

The suggested framework for English as a Foreign Language (EFL) teaching, which merges mathematical modeling based on STEAM principles and innovative technological aids, together with the assimilation of Sociocultural and Self-Determination Theories, could yield noteworthy effects on EFL instructors and professionals (Chen & Liu, 2023; Jones & Lee, 2021). One possible rewording is: The strategy may augment the language competence of EFL pupils by affording them prospects to cultivate their critical thinking and problem-solving abilities through interactive exercises, cooperative study, and digital tools and mathematical simulations. Moreover, the framework has the potential to enhance diversity and inclusivity in EFL pedagogy by fostering a culturally-sensitive and inclusive atmosphere for learning that caters to the unique requirements of diverse learner communities and fosters learner independence (Chen & Liu, 2023; Jones & Lee, 2021). In order to achieve optimal implementation of the framework, it is recommended that EFL educators and practitioners give priority to crafting a curriculum that is congruent with the active learning and problem-solving pedagogical approach inherent in the framework. The aforementioned comprises the fusion of technological innovation and mathematical representation, backing student-driven and participative education, endorsing diversity and inclusiveness, and fostering the advancement of learner independence (Chen & Liu, 2023; Smith, 2022). Through the application of the aforementioned framework, instructors of English as a foreign language can assist in equipping their students to succeed in a swiftly-evolving society (Jones & Lee, 2021; Smith, 2022).

7.3 Future directions for research and practice

Further inquiry is required to establish the viability of the suggested framework in enhancing the language aptitude of English as a Foreign Language students in diverse environments, as elucidated by Smith in 2023. Additionally, a more in-depth inquiry could be conducted to explore the precise implementations of nascent technological resources in the domain of EFL education, such as virtual reality or gamification, with the aim of heightening students' motivation and engagement (Johnson & Lee, 2022). It behooves us to evaluate the efficacy of the structure put in place for the education and professional growth of EFL teachers, as espoused by Tan in 2023. It is imperative to investigate the impact of students' attitudes and beliefs on English as a foreign language (EFL) teaching through the utilization of mathematical modeling and advanced technological tools that are built on STEAM principles, as posited by Choi and Park (2022). Ultimately, it is imperative to investigate the framework's potential for application in alternative language education contexts (Garcia, 2023). In order to facilitate the incorporation of emerging technological tools in EFL instruction, it is imperative to conduct extensive research on the various tech tools and applications

available, as suggested by Johnson and Lee (2022). It is imperative for research to delve into the efficacy of utilizing virtual reality or gamification in EFL schooling to augment pupils' engagement and drive.

In order to revolutionize the instructional theory and practice of English as a Foreign Language (EFL), scholarly investigation may delve into the efficacy of the suggested framework for the education and career growth of EFL instructors, as postulated by Tan (2023). It is imperative to conduct research on the effect of instructional training on English as a Foreign Language (EFL) educators' proficiency and comprehension in incorporating technology and mathematical modeling into their teaching practice. It is recommended that future research investigates the impact of learners' attitudes and beliefs on EFL instruction, with the aim of fostering learner autonomy and catering to the distinct needs of diverse learner groups (Choi & Park, 2022). It is imperative to investigate the influence of cultural and social aspects on students' perspectives regarding English as a foreign language education, incorporating STEAM-based mathematical modeling and innovative technology tools. Although the proposed framework was designed for EFL instruction, it is the duty of researchers to explore the efficacy of the framework in alternative language education settings, such as foreign language instruction or bilingual education (Garcia, 2023). Consequently, the suggested model for instructing English as a Foreign Language, utilizing Science, Technology, Engineering, Arts, and Mathematics (STEAM) based mathematical modeling and up-and-coming technological devices, coupled with the incorporation of Sociocultural and Self-Determination Theories, provides encouraging outcomes for prospective inquiry and application in the realm of language instruction. Subsequent studies may delve into the efficacy of the framework across various circumstances and evaluate the framework's potential for EFL pedagogy and other language education settings. By adopting this approach, the domain of language education can persist in advancing and augmenting pedagogical methodologies to effectively cater to the requirements of students in a dynamically evolving global context.

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