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Systematic Literature Review of Innovative Arabic Language Teaching Strategies in STEM Education: Sociocultural, Linguistic, and Professional Development Perspectives

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ABSTRACT

This systematic literature review investigates innovative Arabic language teaching strategies within the context of STEM education, examining sociocultural, linguistic, and professional development perspectives. The study underscores the importance of equipping students with Arabic language proficiency to thrive in STEM disciplines and highlights the need to understand effective pedagogical approaches for Arabic language instruction. Following the PRISMA guidelines, a comprehensive search across major academic databases yielded a final sample of 12 peer-reviewed articles published between 2020 and 2024. The analysis revealed three salient themes: (1) innovative teaching strategies for Arabic language learning, (2) sociocultural and linguistic considerations in Arabic language teaching and learning, and (3) teacher training and professional development for Arabic language educators. The findings suggest that strategies such as concept mapping, interactive whiteboards, and collaborative learning techniques like the Numbered Heads Strategy can significantly enhance students' grammar proficiency, listening skills, and positive attitudes toward Arabic language learning. Additionally, the review underscores the importance of contextualizing Arabic language instruction within diverse sociocultural and linguistic contexts, promoting inclusive and culturally relevant education. Furthermore, the analysis highlights the pivotal role of teacher training and professional development initiatives, including models like the Arabic Teaching Efficacy Model (ATEM) and investigations into learner agency and active learning strategies for oral reading skills. However, challenges such as addressing the digital divide and providing adequate support for educators are also identified. In conclusion, this systematic literature review offers valuable insights into innovative Arabic language teaching strategies in STEM education, emphasizing the potential of tailored pedagogical approaches, sociocultural considerations, and professional development opportunities in fostering proficient and culturally competent Arabic language speakers.

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1. Introduction

In an increasingly interconnected world, the significance of STEM (Science, Technology, Engineering, and Mathematics) education has become paramount, with its principles extending far beyond the realms of traditional science classrooms [1]. Integrating STEM into educational frameworks offers a multifaceted approach to learning, fostering critical thinking, problem-solving skills, and innovation among students [2]. However, amidst this global movement towards STEM integration, it's essential to acknowledge and address the linguistic diversity present in educational settings, particularly concerning Arabic-speaking regions [3].

Arabic, a language rich in history and culture, serves as the primary means of communication for millions worldwide [4]. As STEM education continues to evolve, there's a growing imperative to explore effective teaching and learning strategies tailored to Arabic-speaking learners [5]. This systematic literature review delves into the intersection of Arabic language instruction and STEM education, emphasizing the pivotal. The role of teacher training and professional development in supporting effective pedagogical practices.

The synthesis of existing literature not only underscores the importance of linguistic diversity in educational contexts but also sheds light on the unique challenges and opportunities presented by the integration of Arabic language instruction within STEM frameworks [6-8]. Through a systematic examination of scholarly works, this review aims to provide insights into innovative approaches, best practices, and emerging trends in teacher training and professional development initiatives geared towards enhancing Arabic language instruction in STEM education.

Despite the growing recognition of STEM education's importance [1] and the vital role of Arabic language proficiency [2], there remains a significant gap in understanding effective strategies for integrating Arabic language instruction within STEM frameworks. Previous studies have largely focused on either STEM education or Arabic language teaching in isolation [3,4], with limited attention to their intersection. Specifically, there is a lack of comprehensive understanding regarding:

i. Innovative pedagogical approaches that effectively combine Arabic language learning with STEM content [5].
ii. The influence of sociocultural factors on Arabic language acquisition in STEM contexts [6].
iii. the specific professional development needs of educators teaching Arabic in STEM settings [7].

Additionally, while existing research has explored language instruction in STEM education broadly [8], the unique challenges and opportunities presented by Arabic language integration in STEM disciplines remain understudied [9]. This systematic review addresses these gaps by synthesizing current research on innovative Arabic language teaching strategies within STEM education, providing insights into effective pedagogical practices, and identifying areas requiring further investigation.

Through a systematic exploration of peer-reviewed literature, this review aims to contribute to the ongoing discourse surrounding language-inclusive STEM education initiatives. By identifying gaps, synthesizing findings, and offering recommendations, it strives to empower educators, policymakers, and stakeholders to foster a more inclusive and equitable learning environment conducive to the holistic development of Arabic-speaking learners in STEM disciplines.

2. Literature Review

Translanguaging has become increasingly acknowledged as an approach to multiliteracy approach in English-medium instruction (EMI) education. However, its application in STEM classroom settings remains insufficiently studied. Additionally, the connection between EMI teachers' professional identities and their instructional strategies have been largely overlooked. This qualitative study examines how STEM academics in an EMI program in China applied translanguaging pedagogy, contributed to the development of their professional identities, and how these identities influenced their use of instructional language in the classroom.

Utilizing nexus analysis, the study charts the intersecting discourses that shape the differing language ideologies and translanguaging strategies of two EMI lecturers. The results underscore the importance of teacher identity and autonomy in managing institutional and classroom discussions, thereby enabling planned and efficient use of translanguaging pedagogy. The research highlights identity challenges within the studied institution, where academic staff wrestled with juggling their roles as proficient EMI teachers and accomplished researchers. This struggle was exacerbated by a prevailing discourse of research meritocracy, which constrained their exploration of translanguaging pedagogy influenced by an internationalism discourse. These challenges weakened their drive to commit to their teaching identities and pedagogical skills.

The study highlights the importance of achieving a balanced perspective on research and teaching, the implementation of stronger teacher assessment systems and institutional backing to promote effective translanguaging pedagogy in EMI. It suggests integrating the construction of teacher identity development into EMI teacher preparedness to foster a more conducive environment for translanguaging practices [9].

In today's diverse K-12 classrooms, there is a pressing need to develop inclusive STEM curricula that reflect students varied social and cultural backgrounds. Transportation is a pertinent topic that can integrate cultural experiences, fostering diversity and inclusion within STEM fields. Culturally responsive teaching (CRT) connects students' cultural backgrounds, languages, and life experiences to their education, yet it remains underutilized in transportation education due to limited educator awareness and understanding.

This research explores the current state of transportation pedagogy and its potential for incorporating CRT via surveys and workshops with pre-service science educators and prospective transportation professionals. The findings highlight five key elements: the evolving inclusivity in STEM curricula, the crucial role of teacher awareness and preparation, the benefits of culturally relevant curriculum topics, the suitability of transportation as a curriculum subject, and persistent barriers like integrating cultural components, privacy, and legal issues. Addressing these gaps can enhance CRT practices in STEM and transportation education, fostering more inclusive learning environments [10].

This study investigates the global perspectives of U.S. four elementary teacher candidates prior to and following their student teaching experience in the People's Republic of China (PRC) from Midwestern-culture families, selected for their readiness to teach, conducted their student teaching in a primary school in Xian, PRC. The focus was on math lessons to explore changes in TCs' global perceptions, particularly the shift from provincial to more refined perspectives. Interviews and class observations were analyzed using an axial coding process to identify changes in the candidates' views. The results showed a significant transformation from a local, parochial perspective to a more global understanding of schooling and culture. This shift was evident across three main axes: (1) global cognitive development, (2) changes in social strategies in varied physical environments, and (3) an increased appreciation of cultural divergence. These three concepts seemed interconnected through a developing sense of justice.

Additionally, the study highlighted the vulnerability of the candidates' proficiency in communicating in a foreign language. However, the findings suggest that teaching math or STEM subjects may be more effective for developing broader global perspectives compared to social studies or language arts. This research underscores the potential of international teaching experiences to enhance global awareness and cultural competence among pre-service teachers [11].

This study examines the language learning beliefs of Chinese engineering undergraduates and their relationship with current teaching materials and curriculum, aiming to enhance both students' learning effectiveness and teachers' instructional strategies. Utilizing Horwitz's Beliefs about Language Learning Inventory (BALLI), the beliefs regarding language learning of 560 engineering undergraduates from eight universities in China were investigated. A mixed-method approach was adopted, employing both quantitative and qualitative tools, with multivariate regression analysis applied to the data.

The findings revealed that the overall language learning situation among Chinese engineering undergraduates is suboptimal, with their prior knowledge at a medium level. Several factors influencing students' language learning beliefs were identified, including aptitude in foreign languages, perceived difficulty of language acquisition, the characteristics of language learning, learning strategies, and communication methods as well as students' motivation and anticipated outcomes. These insights suggest the need for curriculum design that integrates STEM perspectives, advocating for interdisciplinary approaches in English as a second language (ESL) education within engineering programs. By linking these findings with the earlier investigation of U.S. elementary teacher candidates' global perspectives, it becomes clear that international experiences and interdisciplinary approaches significantly contribute to the development of more sophisticated, globalized views in education. Both studies underscore the importance of culturally responsive and interdisciplinary curricula in enhancing students' learning experiences and outcomes, particularly within STEM education [12].

Since the beginning of the COVID-19 pandemic in early 2020, English language learners had to adapt from in-person interactions to online lessons. This study investigates the learning strategies employed by these learners during their sessions conducted online. To accomplish this goal, a survey was conducted with 257 university students enrolled in a compulsory English course. The questionnaire aimed to capture their cognitive, affective, sociocultural, and interactive strategies. The findings revealed several prominent strategies: taking notes, attending recorded lectures, quietly observing online interactions, completing assignments, engaging in chat discussions with classmates, and utilizing internet-based lessons. These strategies reflect a seemingly passive attitude, likely influenced by the Asian cultural context in which the students were raised. A reliable internet connection was crucial for their learning, as well as for playing games and watching movies to alleviate stress and boredom while studying at home. Engaging in chats with classmates fostered a sense of community, likely helping to alleviate feelings of isolation.

Therefore, this study offers insights into how English as a Foreign Language (EFL) learners coped with the challenges of online learning during the pandemic. Besides this, it underscores the importance of reliable internet access and the need for strategies that foster a sense of community among learners. The findings suggest that English teachers should consider these aspects to enhance online teaching and support students' learning experiences effectively. Furthermore, these findings align with previous research highlighting the necessity of culturally responsive teaching methods and interdisciplinary curriculum designs in enhancing students' learning experiences and outcomes. As with studies on global perspectives in teacher candidates and language learning beliefs in engineering students, this study emphasizes the critical role of adaptable, culturally informed educational strategies in navigating unprecedented learning environments [13].

Recent scholarship has highlighted the potential of texts related to sports as a medium for exploring sociopolitical issues. This study explores the methods and materials employed to facilitate an extended exploration of such issues within a secondary sports literature course, and investigates how students recount their experiences engaging with these activities. The study, part of a broader exploration of teaching secondary sports literature, utilizes a qualitative approach. The data collection process comprised interviews, classroom observations, and artifact gathering. Data analysis was conducted iteratively and recursively, employing various validation strategies to ensure trustworthiness.

The findings reveal that the methods and materials used include whole-class readings of the book Season of Life by Marx, edition 2003, and small-group research on debated issues in sports culture. Students found these activities pertinent to their individual interests and experiences, and described them as illuminating in terms of understanding sociopolitical issues in sports and society [14]. This study contributes to the growing body of scholarship advocating for the use of sports-themed content to bolster literacy instruction. It documents new insights into the classroom practices that facilitate the investigation of sociopolitical issues through sports literature and captures students' perspectives on their learning experiences. These findings underscore the value of incorporating sports-related texts into the curriculum to engage students in meaningful discussions about sociopolitical issues [15].

To address text-borrowing practices among language learners, often regarded as plagiarism in the U.S. academic context, educators can implement strategies for teaching writing processes and promoting academic integrity education. This article explores effective methods to mitigate plagiarism by emphasizing comprehensive writing instruction and the integration of academic integrity principles into the learning process. By equipping students with these skills, educators can foster a deeper understanding of original authorship and ethical academic practices [16].

In another study, researchers aimed to develop conceptual frameworks for integrating STEM concepts into Bahasa Indonesia teaching. Utilizing a mixed-methods research design, the study included document analysis, surveys, and a systematic review. The primary objectives were to identify STEM concepts within the fundamental competencies within the Bahasa Indonesia curriculum for Grades 1–3, recommend effective teaching and learning strategies for integrating these STEM concepts, and propose initial conceptual frameworks for teaching STEM within the Bahasa Indonesia curriculum at the elementary level.

The findings revealed that the proposed conceptual frameworks for teaching science concepts within the Bahasa Indonesia curriculum emphasize Bahasa Indonesia as the primary focus, with science concepts serving as a complementary approach. Reading was recommended as the primary instructional strategy. Similarly, the framework for teaching technology concepts also prioritized Bahasa Indonesia as the primary objective, with technology concepts integrated through reading activities.

These results provide valuable insights for Indonesian teachers and educators in other countries that incorporate STEM concepts into language subjects. By using integrated learning strategies, this approach contributes to sustainability education and supports the development of comprehensive educational practices [17].

Globally, students with migrant backgrounds often underperform in school STEM subjects compared to their peers, largely due to lower subject-specific language proficiency, which hinders their participation and learning. Primary teachers face challenges in both teaching STEM and fostering the necessary language development. This study investigates the impact of a professional development program (PDP) designed to enhance inclusive STEM teaching by promoting language-supporting strategies such as interaction, language scaffolding, and the use of multilingual resources.

The study included five case study teachers from multilingual primary schools in the Netherlands (N = 2), Sweden (N = 1), and Norway (N = 2), who taught classrooms with migrant pupils. The professional development program (PDP) centered on three STEM units (sound, maintenance, plant growth) and integrated strategies to promote language development. To monitor the teachers' progress, three interviews were conducted with each teacher — one after each unit — and teachers also filled out digital logs following each unit. The results showed positive shifts in teachers' awareness, beliefs, and attitudes towards strategies that support language development. However, actual changes in teaching practices and intentions to implement these strategies were reported less frequently. This study demonstrates that a PDP can effectively initiate teacher learning for inclusive STEM teaching, while also highlighting potential enablers (e.g., fostering language awareness) and barriers (e.g., limited STEM knowledge) that should be considered in future PDP designs [18].

The increasing diversity in schools, both societal and linguistic, necessitates pedagogical approaches that cater to multilingual pupils. Translanguaging pedagogies provide a conducive learning environment for multilingual learners, enabling them to utilize their linguistic resources effectively. However, research on translanguaging in early childhood education, particularly involving emergent multilinguals and focusing on interactions between adults and children, as well as peer interactions remains limited.

This paper, situated in multilingual Luxembourg, investigates the involvement of two three-year-olds in activities led by adults and children across two early childhood education settings. It also explores how these children creatively integrate translingual activities and strategies during peer interactions. The qualitative study includes data from 128 video-recorded excerpts collected over the course of a year.

The findings highlight the significant influence of pedagogy and practitioners' strategies that support language use and foster active participation among children. In peer interactions, the children creatively reproduce everyday activities, altering formulaic speech and adapting practitioners' strategies. These insights offer valuable guidance for curriculum developers and educators seeking to implement inclusive use of translanguaging practices in early childhood education [19].

The COVID-19 pandemic prompted universities worldwide to transition With the shift to online instruction, concerns have arisen regarding the quality of online courses and their effects on student satisfaction and engagement. This study aimed to investigate the satisfaction levels of Korean university students with online English-mediated instruction (EMI) courses during the pandemic and to identify factors influencing their satisfaction to provide insights for improving online teaching practices. The hypothesis suggested that instructional strategies (IS), academic conscientiousness (AC), and academic integration (AI) might act as mediators in the relationship between engagement and satisfaction. Using a survey design, data were gathered from 219 Korean university students enrolled in online EMI courses during the spring 2020 semester. The survey included demographic information and assessed students' perceptions of instructional strategies (IS), academic conscientiousness (AC), academic integration (AI), and satisfaction. Data analysis encompassed independent samples t-tests, correlation analysis, Structural Equation Modeling (SEM), and multiple regression analysis.

The study's findings revealed disparities in the utilization and contentment with information systems (IS) among students from various academic disciplines, with notable contrasts detected between those majoring in Arts, STEM, Business, Social Sciences, and Literature and Languages. Moreover, the research uncovered significant connections between demographic factors, affective commitment (AC), academic integration (AI), IS usage, and overall satisfaction. Structural equation modeling (SEM) illuminated the mediating roles of AC, AI, and IS use in the relationship between

student engagement and satisfaction. Furthermore, multiple regression analysis suggested that students expressed greater satisfaction with instructors who exhibited care and warmth by employing social networking platforms for communication purposes.

In summary, this research provides important understanding of student contentment with online English-medium instruction (EMI) courses amidst the COVID-19 pandemic and offers recommendations for forthcoming virtual EMI teaching methods. The outcomes imply that educators ought to contemplate harnessing social networking platforms for communication to elevate satisfaction degrees. The study delivers precious perceptions into pupil gratification with online EMI classes during the COVID-19 outbreak and extends direction for prospective online EMI instructional practices. The discoveries propose that instructors should ruminate on utilizing social networking sites for interaction to augment contentment levels., and they should tailor instructional strategies based on discipline-specific needs to optimize student engagement and satisfaction [20].

Intelligent tutoring systems (ITSs) are software programs tailored to individual student needs, while dialog systems enable computer-human communication through natural language. This paper conducts a systematic literature review spanning the past twenty years to explore ITSs incorporating dialog systems. Thirty-three ITSs were identified, addressing five key research questions:

i. Which intelligent tutoring systems incorporating natural language conversation have been created?
ii. In each ITS, what is the primary objective of the tutoring discourse?
iii. What educational attributes define the instructional methodology employed by these systems?
iv. How do these ITSs approach the task of comprehending natural language input?
v. What data is available concerning the assessment and effectiveness of these intelligent tutoring systems?

The review reveals that the majority of ITSs focus on science, technology, engineering, and mathematics (STEM) domains at the university level, with many adopting an approach tailored to students' expectations and misconceptions. Most systems use dialog to guide students in problem-solving tasks at the apply level of Bloom's taxonomy. Instructional approaches include assisting students in writing correct explanations, aiding problem-solving processes, and facilitating reflective dialogues. Empirical evaluations were conducted for 90.91% of the ITSs, assessing learning gains and the effectiveness of tutoring strategies [21].

Preparing today's science teachers to nurture the scientists of tomorrow requires a deep understanding of scientific languages and practices. This may necessitate a shift in the mindset of in-service teachers regarding learning and their role in the classroom. A promising approach, called Argument-based Strategies for STEM-Infused Science Teaching (ASSIST), provides professional development opportunities for K-12 science educators to embrace current science practices, including argumentation.

In the ASSIST program, participating teachers provide self-reflections detailing the challenges encountered when implementing the approach with their learners. These reflections are analyzed using critical discourse analysis (CDA) to identify themes in the language used by participants when expressing challenges in adopting a new teaching approach. The analysis uncovers power struggles at instructional, institutional, and interpersonal levels, hindering progressive teaching and learning approaches.

This research highlights competing educational ideologies as fundamental to these power struggles, which can be elucidated through CDA. The implications for designing professional

development programs for science teachers will be discussed, emphasizing the importance of addressing power dynamics to foster effective pedagogical change [22].

Effective communication hinges on achieving shared understanding, wherein participants agree upon meaning. Without shared understanding, misunderstandings can impede communication and hinder collaborative tasks. This study aimed to investigate how students, pre-service, and current teachers employ various strategies to achieve shared understanding during a spatial visualization activity in a STEM instructional setting.

Data from 15 transcribed recordings were analyzed using constant comparative analysis to discern communication characteristics during clarification exchanges. The findings highlight three essential features of these interactions: confirmation, reevaluation, and misdirection. Participants utilized both precise technical language and everyday analogies to foster shared understanding. Successful exchanges, facilitating task completion, demonstrated the use of language to affirm or progress toward shared vocabulary. Conversely, unsuccessful exchanges, hindering task completion, stemmed from misunderstandings arising from a lack of shared language or meaning.

The study's implications for instructional practices underscore the potential for both everyday language and technical jargon to create confusion. Recognizing the significance of effectively evaluating and addressing students' present understanding is paramount in facilitating effective communication and collaborative learning experiences in STEM classrooms [23].

The COVID-19 pandemic necessitated the sudden transition of transitioning the EAP course for STEM doctoral students at Parma University (Italy) to online delivery, mirroring the shift experienced by academic institutions worldwide. Confronted with this challenge, the teacher faced the daunting task of redesigning the course and adapting strategies for remote teaching within a short timeframe and limited resources.

The primary goal was to preserve the interactivity and group dynamics of the in-person course, despite the transition to online instruction. This shift presented both didactic challenges associated with restructuring a traditionally interactive course and technical obstacles inherent in remote teaching. Additionally, the unexpected situation added emotional and psychological stress for both the teacher and students. Given the diverse academic backgrounds of the students, the focus shifted to developing productive language skills through collaborative tasks aimed at enhancing writing and speaking abilities, rather than solely focusing on academic language proficiency.

This paper reflects on the process of navigating the challenges of remote teaching amidst the pandemic, highlighting elements that contributed to its favorable result, such as strong social connections, the evolution of classroom dynamics and emergent learning points. Practical suggestions are offered to support language teachers worldwide in addressing similar challenges creatively [24].

Introduction to programming courses in STEM degrees are crucial for students' academic and professional success, yet they often face high failure and dropout rates. With an increasing number of publications on this topic, there's a recognized need for an umbrella review to consolidate previous studies and provide comprehensive insights.

This study conducted a formal search across major academic databases, identifying 21 reviews focusing on programming fundamentals in higher education. Results include bibliometric details such as authorship, publication trends, and key articles. Additionally, the study examines the purpose, research questions, methods, and results of these reviews, providing insights into their scope and findings. A taxonomy is presented, categorizing review purposes into four types: general, specific, student group-oriented, and teacher-directed. These findings offer valuable resources for researchers and authors interested in exploring programming education in higher education contexts [25].

Research and research methods courses provide essential components of both undergraduate and graduate academic programs, encompassing both STEM and non-STEM disciplines. However, these courses often present challenges for students, who may perceive the content as complex and intimidating. Many students also struggle with practical applications of learned concepts, finding the content uninspiring and anxiety-inducing. Educators face their own set of challenges in teaching research methods, including diverse methodological content, fragmented expertise, inconsistent curricula, limited resources, and linguistic barriers.

In this paper, we propose strategies to address these challenges and enhance the effectiveness of teaching courses on research and research methods at both undergraduate and graduate levels [26]. The aim of this research is to review recent advancements in language and technology research aimed at enhancing the effectiveness of teaching and learning in engineering. The review encompasses various elements affecting the teaching and learning process, analyzed through bibliometric analysis using the keywords "Language" and "Engineering Learning" sourced from Google Scholar between 2020 and 2022.

Key aspects covered include defining engineering education and highlighting the advantages of technology in this field. The review delves into the purpose and significance of language in formulating teaching strategies, considering factors such as formal and informal learning, educational levels, and curriculum development. The integration of technology in media and laboratories is emphasized as a crucial factor in enhancing literacy and the impact of language on student learning.

Furthermore, the review explores the intertwined nature of language and various student characteristics, motivations, teacher-student relationships, therapy, and psychological conditions. It also addresses language barriers faced by students with exceptional needs and introduces new technologies aimed at improving language skills in teaching.

The results of the co-occurrence study underscore several key points, including the importance of children, mathematics, STEM education, and educators' roles. Ultimately, the research emphasizes that engineering education involves teaching and learning scientific concepts, principles, and practices, where technology plays a vital role. Language serves as a conduit for conveying learning information, underscoring its importance in the engineering field. This paper serves as a valuable reference for educators seeking insights into the crucial role of language in engineering education [27].

This study introduces and assesses the OCEL.AI (Open Collaborative Experiential Learning. AI) paradigm, designed to broaden participation in data science education and enhance undergraduate students' data literacy. Central to this paradigm is the "Tell Stories" approach, which utilizes the 5W+1H (Who, What, When, Where, Why, and How) conceptual schema of storytelling as a transdisciplinary language for data science education across STEM and non-STEM majors.

The study presents findings from the implementation and evaluation of the OCEL.AI project. Through a field experiment and classroom observations, the study compares the differences in learning outcomes among students in data science competence, appreciation, career motivation, lifelong willingness to learn, and self-efficacy between the treatment group and the control group. Results indicate that the OCEL.AI paradigm enhances undergraduates' data science competence and career motivation, irrespective of their majors or gender [28].

This study evaluates the sequencing impact of merging science and arts within a large-scale investigation of NGSS-aligned STEM methodologies. The goal is to offer more fair learning opportunities, especially for students who are emerging bilingual (EB) and fluent in English (EF). T-tests and analysis of covariance examine the impact of teaching sequence, language skills, and teachers' adherence to implementation. Results indicate significantly higher science learning gains for both English-fluent (EF) and emerging bilingual (EB) students with the STEAM-first approach,

particularly advantageous for EB students overall. Even in environments with low to moderate fidelity classrooms, the STEAM-first order benefits EB learners significantly. This suggests a compensatory advantage for EB students, enhancing equity in science learning opportunities. Teaching science through STEAM lessons, especially with a STEAM-first order effect, is effective and promotes equitable learning outcomes for EB and EF students [29].

Successfully completing a high-quality Algebra course by 8th grade is crucial for entering STEM majors. Thus, ensuring equitable best practices in this critical course is crucial for supporting STEM recruitment and retention. However, if the research base for Algebra overlooks certain student populations, it may inadvertently perpetuate structural inequities in evidence-based practices. This synthesis aims to examine how qualitative research on Algebra strategies addresses equity issues, including gender, socioeconomic status (SES), rural students, special education status, ethnicity, and native language. Using qualitative research integration techniques, fifty-eight studies on Algebra 1 teaching strategies were summarized.

Most of the studies identified constructivism, social constructivism, and situated cognition as theoretical frameworks, or did not explicitly mention a framework. Most research questions focused on the effectiveness of specific pedagogical techniques or interventions. Results indicate that study participants were predominantly Caucasian students from suburban areas, lacking sufficient detail for replication [30].

3. Material and Methods

This systematic review employs a comprehensive mixed-methods approach to ensure a thorough analysis of Arabic language teaching strategies in STEM education. The methodology combines quantitative analysis, including bibliometric analysis of publication trends, statistical analysis of intervention effectiveness, meta-analysis of effect sizes where applicable, and frequency analysis of teaching strategies and their outcomes. For qualitative analysis, the study incorporates thematic analysis of teaching approaches, content analysis of pedagogical frameworks, synthesis of sociocultural considerations, and narrative synthesis of professional development strategies. The integration of both quantitative and qualitative approaches enables triangulation of findings, comprehensive understanding of complex educational phenomena, robust evidence-based recommendations, and identification of patterns across multiple studies.

The data abstraction and analysis process involved several stages. For quantitative data analysis, we conducted calculations of effect sizes for intervention studies, statistical aggregation of reported outcomes, meta-regression where appropriate, and frequency analysis of teaching strategies. The qualitative data synthesis included coding of key themes and concepts, identification of emerging patterns, analysis of contextual factors, and integration of pedagogical approaches. The analysis process was conducted iteratively, with findings from both quantitative and qualitative analyses being integrated to provide comprehensive insights into effective Arabic language teaching strategies in STEM education.

3.1 Identification

In conducting a systematic review for this report, we followed a three-phase process. The first phase involved identifying keywords and searching for related and synonymous terms using thesauri, dictionaries, encyclopedias, and previous studies. Once the relevant keywords were determined, we created query terms for Scopus and ERIC databases (see Table 1). This initial step in the systematic review process led to the successful retrieval of 12 papers from both sources.

Table 1
The search strings

Scopus	TITLE-ABS-KEY (teaching AND strategy AND arabic) AND (LIMIT-TO (SUBJAREA , "SOCI")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Arabic")) AND (LIMIT-TO (EXACTKEYWORD , "Teaching") OR LIMIT-TO (EXACTKEYWORD , "Arabic") OR LIMIT-TO (EXACTKEYWORD , "Arabic Language") OR LIMIT-TO (EXACTKEYWORD , "Education"))
ERIC	https://eric.ed.gov/?q=teaching+AND+strategy+AND+arabic&ff1=dtySince_2020&ff2=subTeaching+Methods&ff3=subArabic&ff4=pubJournal+Articles

3.2 Screening

In the preliminary screening phase, duplicated papers were excluded, resulting in the omission of 1 article. In the second phase, 38 articles were screened using several inclusion and exclusion criteria established by the researchers. The primary criterion was that the literature needed to be research articles, for the purpose of this research, only primary sources of empirical data were considered. Consequently, secondary sources such as systematic reviews, literature reviews, meta-analyses, meta-syntheses, book series, books, chapters, and conference proceedings were omitted from the analysis. The focus was placed on original studies that provided direct, firsthand information relevant to the research questions at hand. By concentrating on these primary sources, the study aimed to gather the most up-to-date and reliable data available, ensuring that the findings were grounded in concrete evidence rather than relying on aggregated or summarized information from secondary sources.

Furthermore, the review was restricted to papers in English and Arabic. The selected timeframe for the study was a five-year period (2020–2024). Only studies conducted within all countries were included to align with the analysis objectives. Overall, based on these specific parameters, 334 publications were excluded.

3.3 Eligibility

In the third step, known as the eligibility phase, a total of 38 articles were prepared for further review. At this point, the titles and main content of all articles were thoroughly examined to ensure they fulfilled the inclusion criteria and corresponded with the current research aims. Consequently, 26 reports were excluded because they did not empirical social science articles. Ultimately, 12 articles were considered suitable for review (see Table 2).

Table 2
The criteria used for searching

Criterion	Inclusion	Exclusion
Language	English, Arabic	Non-English, non-Arabic
Time line	2020 – 2024	< 2020
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press
Subject Area	Social Science	Besides Social Science
Country	All	-

3.4 Data Abstraction and Analysis

The systematic review process was carried out in three main phases: identification, screening, and eligibility. The PRISMA flow diagram (Figure 1) illustrates the flow of information through these phases.

Identification:

i. The initial search strategy involved identifying relevant keywords and search strings, which were used to retrieve articles from the Scopus and ERIC databases.
ii. This phase resulted in the retrieval of 12 papers.

Screening:

i. Duplicated papers were excluded, resulting in the omission of 1 article.
ii. The second phase of screening involved applying inclusion and exclusion criteria to 38 articles.
    a. Inclusion criteria: Research articles providing practical information.
    b. Exclusion criteria: Systematic reviews, reviews, meta-analyses, meta-syntheses, book series, books, chapters, conference proceedings, and non-English papers.
    c. Timeframe: 2020–2024.
    d. Geographic focus: Studies conducted in Malaysia.
iii. As a result, 334 publications were excluded according to these criteria.

Eligibility:

i. During the eligibility phase, the titles and key content of 38 articles were reviewed to ensure they met the inclusion requirements.
ii. Two reports were omitted as they were not empirical science articles.
iii. Finally, 12 articles were included for review.

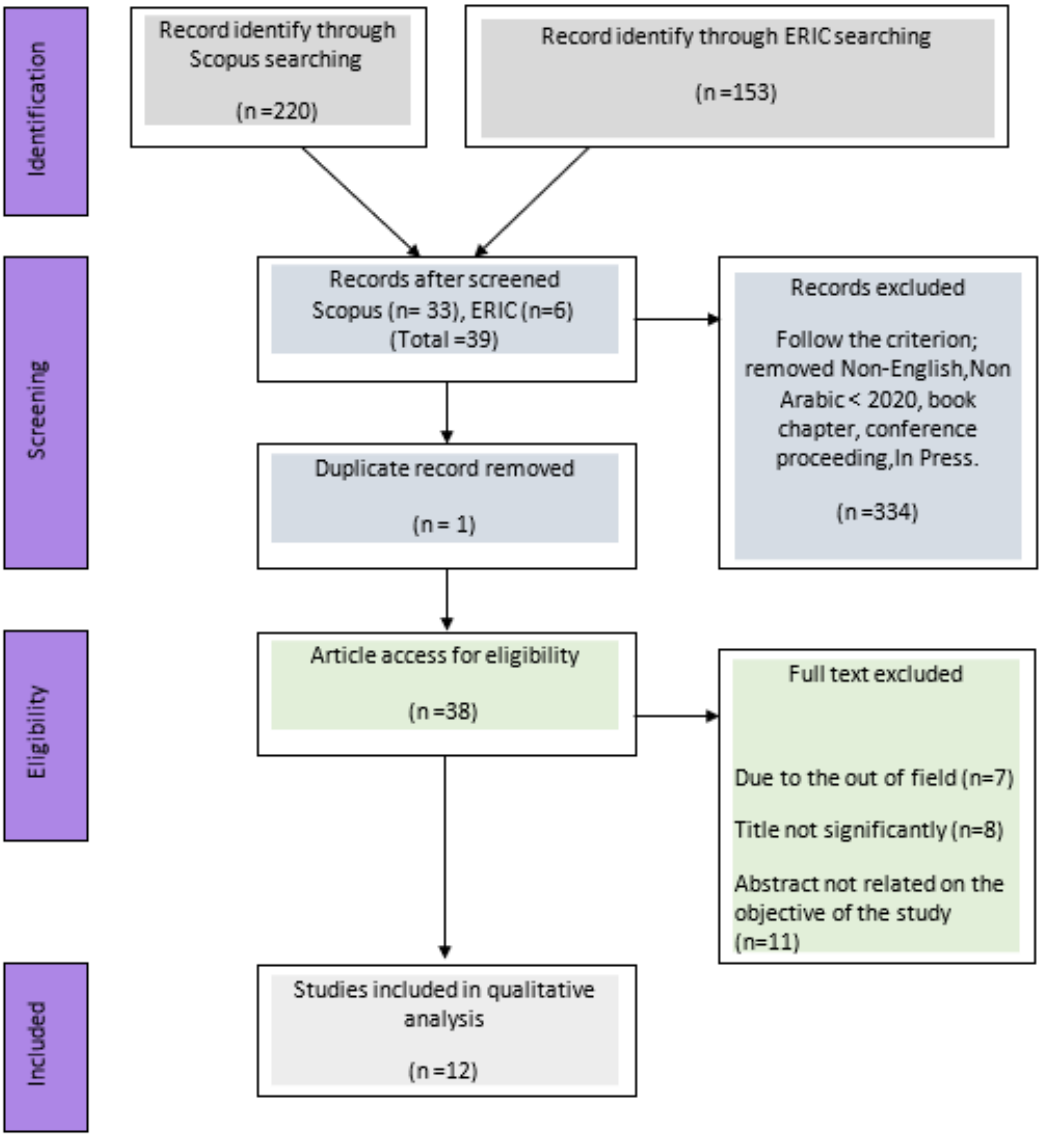

Fig. 1. PRISMA Flow Diagram of the proposed searching study [31]

The PRISMA flow diagram visually represents the number of records identified, included, and excluded throughout the systematic review process. It provides a clear and transparent summary of how many records were filtered at each stage, ensuring the reproducibility and transparency of the research.

4. Result and Findings

4.1 Theme 1: Innovative Teaching Strategies for Arabic Language Learning

Concept mapping is a powerful teaching and learning strategy that has proven to be effective for both students and educators. This study sought to investigate the impact of using concept mapping on the Arabic grammar proficiency of students at Al Ain University. The research sample consisted of 56 Arabic language students, split into an experimental group consisting of 29 students and a control group consisting of 27 students. To ensure the equivalence of both groups, pre- and post-tests were administered.

The experimental group received instruction on six grammatical topics using the concept mapping approach, whereas the control group taught the same topics using traditional methods

without the use of concept maps. The study's findings revealed statistically statistically significant differences between the two groups, with the experimental group achieving better results than the control group. Moreover, the results also indicated significant differences between male and female students in the grammar achievement test, with females exhibiting higher proficiency.

These findings underscore the crucial role of concept mapping in teaching grammatical concepts. The inherent characteristics of concept mapping, such as its organized and logical sequencing of concepts, align well with the nature of grammar, which is known for its logical structure and hierarchical construction. Consequently, the study recommends the implementation of concept mapping for teaching grammar in Arabic language courses at the university level. This can be achieved by designing Arabic course content in accordance with the concept mapping strategy and incorporating examples of relevant concepts within these courses to facilitate their use by teachers. [32].

The Impact of Interactive Whiteboards on Enhancing Arabic Listening Skills Aldhafiri [32] conducted a study to examine the efficacy of interactive whiteboards (IWBs) in enhancing the Arabic listening skills of undergraduate students majoring in Arabic language at Kuwaiti universities in the second semester of the 2018/2019 academic year. The literature review suggests that interactive whiteboards enhance language learning and boost students' listening skills and motivation. The study sample consisted of 60 male students, evenly split into an experimental group and a control group. The experimental group was taught using the interactive whiteboard strategy, whereas the control group received instruction through traditional methods.

The researcher analyzed the pretest and posttest scores of both groups with the Statistical Package for the Social Sciences (SPSS) software. The findings revealed statistically significant differences between the groups at the $\alpha \leq 0.05$ level, favoring the experimental group. The results indicated that (1) the interactive whiteboard strategy led to better improvement among students compared to using the traditional method; (2) the effect size of interactive whiteboards was substantial; and (3) there were statistically significant differences between the mean posttest scores of the two groups in Arabic listening skills, with the experimental group outperforming the control group. Based on these findings, the researcher suggests that interactive whiteboard strategies can be effectively utilized for teaching Arabic listening skills owing to their positive influence on student achievement scores. The study finds by suggesting areas for future research in various contexts [33].

This study aimed to investigate the effectiveness of the Numbered Heads Strategy in enhancing oral expression skills and attitudes among multilingual Arabic learners. The research involved 50 male and female participants at the intermediate level of a language center within Al al-Bayt University. The Participants were allocated into two groups: a control group receiving conventional instruction and an experimental group instructed using the Numbered Heads Strategy. The researchers created an achievement test and an attitudinal scale to evaluate the participants' oral expression skills and attitudes towards the teaching method.

The results revealed that the experimental group had a statistically significant higher mean scores in both one of oral expression skills tests and post-attitude scales. In other words, when considering the interaction between teaching strategy (GCE vs Other) and gender there were no significant differences in the mean scores of boys or girls from experimental schools relative to control school children on oral expression test and attitude scale accommodations. The results of this study recommend using the Numbered Heads Strategy while teaching oral expression skills to non-native speaking Arabic learners because it has been successful in improving students' skills and attitudes [34]. Table 3 presents the results of a two-way ANCOVA analysis examining the performance of the study sample based on teaching strategy, gender, and their interaction, assessing the effectiveness of the Numbered Heads strategy in evaluating attitudes ttabblowards oral expression skills.

Table 3
Results of a two-way ANCOVA analysis examining the performance of the study sample based on teaching strategy, gender, and their interaction, assessing the effectiveness of the Numbered Heads strategy in evaluating attitudes towards oral expression skills

Source	Type sum of squares	df	Mean square	F	Sig (P)	Eta squared η^2
Pretest	0.222	1	0.222	2.849	0.098	0.060
Teaching Strategy	1.967	1	1.967	25.199	0.000	0.359
Gender	0.194	1	0.194	2.480	0.122	0.052
Method × Gender	0.207	1	0.207	2.652	0.110	0.056
Error	3.513	45	0.078			
Modified Total	6.645	49				

The study found that the numbered heads teaching strategy had a significant positive impact on students' attitudes towards oral expression skills compared to the conventional teaching method. The findings indicated:

i. A statistically notable difference in attitudes between the experimental group (utilizing the numbered heads strategy) compared to the control group (taught conventionally), with the experimental group having higher modified mean scores.
ii. The numbered heads teaching strategy accounted for 35.9% of the variability in students' attitudes towards oral expression skills.
iii. There were no significant distinctions observed between the two groups' attitudes based on the interaction between the teaching strategy and gender, indicating that these variables are independent.

The beneficial effect of the numbered heads strategy on students' attitudes may be attributed to:

i. The friendly, interactive, and collaborative learning environment it creates.
ii. The freedom it gives students to express their ideas and appreciate others' perspectives.
iii. The principles of the strategy, such as encouraging brainstorming and discouraging criticism, which increase students' enthusiasm and motivation for learning.

Overall, the numbered heads strategy has been shown to improve students' communication skills and attitudes towards oral expression.

4.2 Theme 2: Sociocultural and Linguistic Considerations in Arabic Language Teaching and Learning

This article examines how Jordanian textbooks and curricula for teaching the Arabic language contribute to the construction of a connection between national and Islamic identity. The study begins by discussing the historical significance of the Arabic language in discourses on Islam, Islamism, and Arabic nationalism. It then provides a historical overview of how nationalism, religion, and religious diversity have influenced Jordan's educational and political strategies.

The paper is built around the exploitation of Arabic, understood in both an Islamic and a national sense. This article undertakes a comparative analysis reference to the 2013 Arabic Language Curriculum and the 2019 General Framework for Jordanian Curricula, accompanied by referring

content material textbooks. Based on the teaching policies as pragmatic needs, which is results of this study - it could be seen within a wider historical and political context in Jordan. The findings underscore the importance of the Arabic language in constructing identities in the contemporary Middle East and highlight its ongoing politicization. A comparison between the 2013 and 2019 documents reveals significant changes in the formulation of the relationship between language and religion, with a reduced emphasis on this connection in the more recent document.

By examining the role of Arabic language teaching in shaping national and Islamic identity in Jordan, this article contributes to our understanding of the complex interplay between language, religion, and politics in the region [35].

Exploring the Social and Cultural Aspects of Arabic Language Education in a Thai Muslim Minority School. This study investigates the integration of Arabic language education at Maitreechit Withayattan School in Bangkok, Thailand, focusing regarding the obstacles and opportunities for advancing Arabic language education in a setting dominated by a Muslim minority. The research considers Thailand's unique position as an ASEAN country with a legally recognized Muslim minority and examines factors such as student engagement, instructional approaches, implicit learning objectives, and the role of educators in the learning process.

Using modern ethnographic methods, the researchers conducted their study at the Maitrechit Wittaayathan School in Bangkok. The findings reveal that students' low interest in Arabic language learning is influenced by a lack of innovative instructional strategies and a requirement for additional diverse learning approaches. The study also uncovers hidden learning goals, including students' political aspirations to support the position of Muslims in government, which adds complexity to the dynamics of Arabic language learning. One significant finding is the importance of Arabic language skills within the governmental framework, where students are instructed that proficiency in Arabic can provide a competitive advantage in government sector careers. Despite challenges related to student interest, the school administrators' commitment to Arabic language education creates opportunities for strong collaboration between education and the cultivation of religious identity.

The implications for managing Arabic language education necessitates additional engaging learning methodologies, educator preparation, and partnerships with external entities to enhance the alignment of education with future career prospects. While this research provides valuable insights into the intricate dynamics of Arabic language education within a Muslim minority school environment in Thailand, it is important to note that the findings are constrained to a single school in Bangkok and should be generalized with caution [36].

Investigating the Challenges of Translating Time Metaphors between English and Arabic. This study explores the similarities, differences, and translation challenges associated with time metaphorical expressions in English and Arabic. The research focuses on the difficulties faced by student-translators when translating these expressions, the strategies they employ, and the reasons behind their translation weaknesses. The study analyzes a sample of English and Arabic temporal metaphors containing words such as second, minute, hour, day, year, age, era, epoch, eternity, and time.

The findings reveal that time metaphorical expressions can be categorized into four groups: (i) identical in form and meaning across both languages (e.g., golden age, around the clock); (ii) similar in meaning but different in wording (e.g., wait for ages); (iii) existing in English but lacking equivalents in Arabic (e.g., time is money); and (iv) existing in Arabic but lacking equivalents in English (e.g., tremors of the day of judgment). Specialized expressions commonly have direct counterparts (e.g., Stone Age).

The study shows that student-translators correctly translated fewer than 20% of the test items and left many blank. Time metaphorical expressions that are equivalent in both languages were

easier to translate, while opaque expressions with figurative or metonymic meanings and culture-specific ones proved to be more challenging (e.g., too old, obsolete; unimportant individuals discussing critical matters). Expressions requiring specialized background knowledge (e.g., Cretaceous Period) were also difficult for the student-translators.

The participants employed various strategies in translating time expressions, including word-for-word translation, incomplete translation, paraphrasing, using synonyms, and extraneous translations. The study concludes by providing results and recommendations for translation pedagogy, emphasizing the need to address the challenges faced by student-translators when dealing with temporal metaphors in English and Arabic [37].

In the realm of language, words often transcend their literal meanings, weaving intricate tapestries of context and culture. This study embarks on a fascinating exploration of the Arabic words "dar" and "bayt" and their English counterparts "house" and "home," shedding light on the linguistic, translational, and cultural nuances that shape their usage.

The research dives deep into the multifaceted nature of these expressions, aiming to unravel the diverse meanings and contexts in which they are employed. By comparing and contrasting "dar," "bayt," "house," and "home," the study illuminates the instances where these terms are identical in form and meaning, where they diverge in translation, and where they stand alone, untranslatable in the other language.

Through the lens of a corpus comprising 200 Arabic expressions, the study unveils the rich tapestry of meanings associated with "dar" and "bayt." These words, though literally translating to "house" and "home," transcend their physical boundaries, encompassing concepts of family, origin, and identity. They find their way into the names of cities, monuments, and even the dwellings of animals. They permeate the realms of religion, finance, literature, and beyond, painting vivid pictures of the human experience.

However, the path from one language to another is not always smooth. A translation test reveals the challenges faced by student translators, with a mere 25% of expressions accurately translated and many left untouched. The art of literal translation, though common, proves insufficient in capturing the essence of these expressions.

Through this study, we embark on a journey that goes beyond the surface level of words, delving into the heart of language and culture. The findings beckon us to reconsider our approach to translation pedagogy, emphasizing the need to bridge linguistic, cultural, and contextual gaps. By unraveling the intricacies of "house" and "home" in Arabic and English, we open doors to a deeper understanding of the human experience, one that transcends the boundaries of language itself [38].

The choice of instructional medium in EFL classrooms has long been debated. This study investigates the effects of code-switching compared to target-language-only teaching strategies for beginner Saudi EFL students' reading comprehension and their affective experiences, based on their perceptions. It also examines if there are notable distinctions in students' perceptions of the impact of these two strategies on their learning and emotional support. Additionally, the study explores students' preferences regarding the use of code-switching or target-language-only instruction in the classroom and their reasons for these preferences. Data were collected from 52 female Saudi college students through a questionnaire and follow-up interviews. The findings indicate that participants had positive perceptions of the impact of code-switching on their learning and affective experiences in EFL reading classes, contrasting with negative perceptions of target-language-only instruction. There were significant differences in their perceptions of the two instructional strategies, with a preference for code-switching. The study recommends the use of code-switching as an effective teaching strategy for beginner EFL learners to provide emotional support and enhance the understanding of the input [39].

This paper explores the main challenges in translating idioms between English and Arabic and the strategies employed by Algerian learners of English as a Foreign Language (EFL) to overcome these difficulties. A translation test consisting of 18 sentences—9 in English and 9 in Arabic— [40]–[44] was administered to thirty Algerian postgraduate EFL students at Oran University in Algeria. The accuracy of collocation translations was evaluated based on these sources, and the strategies used were identified and analyzed using Excel to calculate frequencies and percentages.

The results demonstrated that the participants' general performance was unsatisfactory, with only 11.85% of collocations accurately translated from Arabic to English and 27.03% from English to Arabic. Collocations with the "Adjective + Noun" pattern were particularly challenging, largely due to the students' limited knowledge of target language adjectives and their semantic nuances, leading to the excessive use of near-synonymous adjectives. Translating collocations from English to Arabic proved more difficult than the reverse. To cope with their unfamiliarity with collocations, the EFL learners resorted to strategies such as literal translation, synonymy, reduction, deletion, paraphrasing, and over-generalization. The study concludes that there is a need to integrate English collocations into the Algerian school curriculum, develop appropriate instructional materials and programs for teaching collocations, and prioritize the teaching of word combinations in the classroom [45]. Table 4 presents various translation strategies used to render English collocations into Arabic.

Table 4
Translation Strategies of Collocations from English to Arabic

No. Collocation	Equivalence	Incorrect	Literal Translation	Synonymy	Reduction	Deletion	Paraphrase
1	14	-	2	12	-	-	2
2	1	-	10	19	-	-	-
3	19	-	2	7	-	-	2
4	2	8	12	1	2	4	1
5	4	-	20	4	0	1	1
6	10	-	20	-	0	-	-
7	-	-	21	6	3	-	-
8	23	2	5	-	-	-	-
9	-	3	19	8	-	-	-
Frequency	73	13	111	57	5	5	6
Percentage	27.03%	4.81%	41.11%	21.11%	1.85%	1.85%	2.22%

The study analyzed the strategies used by EFL students when translating English collocations into Arabic. The participants' overall performance in translating collocations from English to Arabic was better than their performance in translating from Arabic to English, but still considerably low. The most frequently used strategy was literal translation (41.11%), indicating that participants were not familiar with the English collocations and resorted to word-for-word translation, which often resulted in non-native-like, awkward, or misleading expressions. Participants struggled to find equivalent adjectives when translating collocations with the Noun + Adjective form, often using adjectives with similar but not identical meanings due to insufficient vocabulary.

4.3 Theme 3: Teacher Training and Professional Development for Arabic Language Educators

This study examines the role of self-efficacy (S-e) in Arabic language teaching and proposes a comprehensive teaching model that includes goals, materials, and strategies. Drawing on Bandura's research and other studies on S-e theory, the model is designed based on characteristics of materials that enhance S-e in students through three different methods. The proposed Arabic Teaching Efficacy

Model (ATEM) aims to enhance objective thinking, critical analysis, responsiveness, and student perseverance through active mastery experiences, vicarious experiences, verbal encouragement from others, social recognition, and reinforcement of physiological and emotional aspects. ATEM suggests using themes like Science and Technology, What Do You Think?, I Can Speak Arabic, I Speak Arabic Every Day, What Is Your Experience?, Other People's Experiences, and Respect for Others as teaching materials. The model also suggests teaching strategies like social modeling, social persuasion, additional feedback, and group work to enhance teaching effectiveness [46].

The COVID-19 pandemic necessitated a swift transition from in-person to online learning in higher education, compelling university students to become more self-directed with minimal assistance from lecturers or peers. This scenario highlights the increasing need to study learner agency, a topic that remains underexplored. This study investigates the agency of first-year university students in online Arabic language learning, focusing on their intention, motivation, self-regulation, and self-efficacy in both synchronous sessions via Google Meet and asynchronous activities on Edmodo.

Employing an exploratory research method, the study involved 76 first-year students from an Islamic public university in Jakarta, Indonesia. The results indicate that these students possess relatively high levels of intention, motivation, self-regulation, and self-efficacy in online Arabic learning. However, a closer examination reveals that students often lack the information and preparation needed to achieve their goals, show limited motivation to converse with native Arabic speakers, have shallow learning commitments, and are less confident in their performance.

One practical implication of these findings is the need to introduce first-year students to various self-directed learning strategies for Arabic. Lecturers can support this by not only delivering content but also promoting essential skills during their teaching practices [47].

Reading is a complex cognitive activity that involves recognizing, comprehending, and analyzing linguistic symbols. Reading proficiency is crucial as it functions as an educational resource, a means for gaining knowledge and skills, and fosters the enhancement of cognitive, linguistic, and physical abilities. This study examined the impact of active learning strategies on the oral reading skills of low-achieving second-grade students in remote areas of Jordan. The study involved 170 students, from which a sample of 20 low-achieving second-grade students (11 females and 9 males) was purposefully selected based on their grades (below 60%) in the Arabic language course.

A design using a pre-experimental approach with a one-group pretest-posttest approach was employed. Seventeen oral reading skills that the students were required to master were identified. Over a span of seven weeks, the participants were instructed using active learning strategies such as inviting guest speakers, learning through play, storytelling, and peer education. The results indicated statistically significant improvements in the students' oral reading skills due to the implementation of these active learning strategies.

The study suggests a stronger focus on the fundamentals of teaching Arabic, especially for students in the first three grades. Additionally, it advocates for the use of employing active learning strategies to improve students' oral reading skills, as deficiencies in these skills can result in academic setbacks and have adverse impacts on their academic trajectories [48].

The current study aimed to investigate the effectiveness of active learning strategies in developing the oral reading skills of second-grade students. The researchers began by determining the general objective of the study and selecting the appropriate educational content. They then identified 17 critical oral reading skills that the students in the study sample found challenging, leading to a negative impact on their grades by the conclusion of the first semester.

After securing the required permissions from school administrators and parents, the researchers established a seven-week timeline for the study, spanning from October 2, 2022, to December 21,

2022. During this period, they implemented active learning strategies through 30 training sessions designed to target each of the selected oral reading skills.

To assess the students' progress, the researchers conducted pre- and post-tests that required require each student to read aloud a designated text according to the provided instructions. A member of the research team and an educator collaborated in completing a rubric that assigned a assign a score for each student for each of the 17 skills used to evaluate their oral reading proficiency abilities.

By following this structured procedure, the researchers aimed to gather data that would demonstrate the potential of engaged learning approaches in enhancing the oral reading competence of second-grade students. Table 5 outlines the key components of educational content; oral reading skills, training tools, and training session strategies.

Table 5
Educational content - Oral reading skills, training tools, and training session strategies

Number of training sessions	Aim of the training session	Tools used in the training session	Strategies used in the training session
1	Acquainting and informing the students about the objectives of the study		
2	Pronouncing diacritic text without deleting, substituting, or adding a letter or letters	• Blackboard • worksheets	• Visiting guest • Learning by playing
3-5	Pronouncing "al" with sun and moon letters • Distinguishing between the different forms of "ta" and "ya," i.e., tied "taa", open "taa", and "ya" at the end of words	• cubes • drawings • school book • smartphones	• Telling the story • Peer education
6-7	Distinguishing between the different forms of nunation (Fath, Kasr, and Dhamm)	• stories • cards	
8-9	Pronouncing conjunctive and disjunctive Hamza	• notebook	
10-16	• Pronouncing short vowel marks and long vowels • Reading diacritic words aloud • Paying attention to punctuation while reading		
17	Reading diacritic sentences aloud		
18-20	Visually analyzing words to identify their parts		
21-24	Reading syllables aloud		
25-30	Reading a paragraph aloud with proper expression		
1-30	• Visually analyzing words to identify their parts • Reading text aloud with proper speed • Reading out loud clearly • Following correct reading habits, such as holding books, sitting in the correct position, borrowing the book, communicating with colleagues, and cooperating with others		

5. Discussion and Conclusion

5.1 Limitation and Generalizability

While this systematic review provides valuable insights into Arabic language teaching strategies in STEM education, it is important to acknowledge both the strengths and limitations of generalizability. The review encompasses studies from diverse geographical contexts, including Malaysia, Indonesia, Jordan, Thailand, and other Arabic-speaking regions, providing a broad perspective on teaching approaches across different educational systems. The included studies represent various educational levels, from primary to tertiary education, and different types of

institutions, ranging from public schools to universities. This diversity strengthens the generalizability of our findings across multiple educational contexts.

However, some limitations should be noted. First, the majority of included studies focused on formal educational settings, potentially limiting generalizability to informal or alternative learning environments. Second, while the review included studies from multiple countries, there may be underrepresentation of certain regions, particularly from non-Arab speaking countries where Arabic is taught as a foreign language. Third, variations in educational policies, cultural contexts, and resource availability across different regions may influence the effectiveness and applicability of the identified teaching strategies. Future research would benefit from more comprehensive cross-cultural studies and investigations in diverse educational contexts to further validate and expand upon these findings.

An additional significant limitation of this systematic review concerns its temporal scope. Most studies included focused on immediate or short-term outcomes of Arabic language teaching strategies in STEM education, with limited attention to long-term impacts. The absence of longitudinal data restricts our understanding of several crucial aspects:

i. The sustainability of language acquisition gains over time
ii. The long-term effectiveness of various teaching strategies.
iii. Changes in student engagement and motivation across extended periods.
iv. The lasting impact on academic and professional success in STEM fields. This temporal limitation highlights a critical need for longitudinal research in this field.

This temporal limitation highlights a critical need for longitudinal research in this field.

Future research directions should prioritize longitudinal studies that track students' progress over extended periods, ideally spanning multiple academic years. Such studies could examine the retention and development of Arabic language skills in STEM contexts over time, the evolution of student attitudes and engagement with Arabic-STEM integrated learning, the long-term impact on academic achievement and career choices, the sustainability and adaptability of teaching strategies across different educational levels, and the progressive development of teacher competencies and teaching effectiveness. Longitudinal research would provide valuable insights into the enduring effectiveness of teaching strategies and help identify factors contributing to sustained success in Arabic language acquisition within STEM education.

5.2 Implementation Framework

Based on the synthesis of findings, we propose a comprehensive implementation framework to guide educators in effectively integrating Arabic language teaching strategies within STEM education. This framework encompasses several key dimensions essential for successful implementation. The first dimension focuses on pedagogical integration, where educators are encouraged to blend concept mapping with STEM content delivery, incorporate interactive technologies like whiteboards for engagement, and implement collaborative learning approaches such as the Numbered Heads Strategy. Teaching methods should be adaptable based on student proficiency levels and learning needs. Professional development support forms the second crucial dimension. This includes providing regular training on innovative teaching technologies, organizing workshops on integrating Arabic-STEM content, establishing mentoring programs for new teachers, and maintaining continuous assessment and feedback mechanisms. These support systems ensure educators are well-equipped to implement effective teaching strategies. Resource development and management

constitute the third dimension, emphasizing the creation of bilingual STEM teaching materials, development of digital learning resources, and establishment of language-STEM resource centers. Regular updating of teaching materials ensures content remains relevant and effective. The fourth dimension involves assessment and monitoring processes. This includes regular evaluation of student progress, systematic collection of feedback from stakeholders, continuous improvement of teaching strategies, and documentation of best practices. These elements ensure the effectiveness of implemented strategies and facilitate necessary adjustments. Cultural and contextual considerations comprise the fifth dimension, focusing on adapting materials for local contexts, integrating culturally relevant examples, considering student backgrounds, and implementing community engagement strategies. This ensures teaching approaches are culturally responsive and contextually appropriate. The final dimension addresses institutional support, emphasizing the need for administrative backing, infrastructure and technology support, adequate resource allocation, and creation of supportive learning environments. This institutional commitment is crucial for successful implementation of the proposed strategies. This comprehensive framework provides a structured approach for institutions and educators to implement effective Arabic language teaching strategies in STEM education. Success requires commitment at all levels, from individual teachers to institutional leadership, and should be adapted based on specific contextual needs and available resources. Table 6 presents the key components of the implementation framework components and action steps.

Table 6
Implementation Framework Components and Action Steps

Dimension	Key Components	Implementation Actions	Expected Outcomes
Pedagogical Integration	•Concept mapping integration	• Design integrated lesson plans	•Enhanced student comprehension
	•Interactive technology use	• Set up digital learning tools	•Increased engagement
	•Collaborative learning methods	•Organize group activities	•Improved participation
Professional Development	•Technology training	•Conduct regular workshops	•Enhanced teaching competency
	•Content integration skills	•Establish mentoring system	•Better content delivery
	•Assessment techniques	• Provide continuous support	•Improved assessment quality
Resource Management	•Bilingual materials	•Create teaching resources	•Better resource accessibility
	•Digital resources	•Develop online content	•Enhanced learning materials
	•Learning support tools	•Establish resource centers	•Comprehensive support system
Assessment & Monitoring	•Progress evaluation	•Implement tracking systems	•Regular progress updates
	•Feedback collection	•Create feedback mechanisms	•Continuous improvement
	•Performance tracking	•Document best practices	•Evidence-based adjustments
Cultural Integration	•Local context adaptation	• Customize materials	• Cultural relevance
	•Cultural consideration	•Include cultural elements	•Better student connection
	•Community engagement	•Organize community activities	• Increased support
Institutional Support	•Administrative backing	• Secure resources	• Sustainable implementation
	•Infrastructure support	•Provide technical support	• Reliable system support
	•Resource allocation	•Plan budget allocation	•Adequate resource provision

6. Conclusion

The comprehensive examination of Arabic language teaching and learning across the three themes underscores the multifaceted nature of this domain. Firstly, innovative teaching strategies, such as concept mapping, interactive whiteboards, and collaborative learning approaches like the Numbered Heads Strategy, demonstrate their effectiveness in enhancing various aspects of Arabic language acquisition within the STEM education context. These strategies not only improve proficiency in grammar and listening skills but also foster positive attitudes towards language learning among students.

Secondly, the exploration of sociocultural and linguistic considerations reveals the intricate interplay between language, identity, and culture. From the examination of Arabic language teaching in Jordan and Thailand to the analysis of time metaphors and linguistic issues, these studies highlight the importance of contextualizing language instruction within diverse cultural and sociopolitical contexts. They emphasize the need for critical reflection on language policies, curriculum materials, and teaching approaches to promote inclusive and culturally relevant language education.

Lastly, the studies on teacher training and professional development underscore the pivotal role of educators in facilitating effective Arabic language instruction. Models like the Arabic Teaching Efficacy Model (ATEM) offer comprehensive frameworks for enhancing teaching effectiveness and promoting student self-efficacy. Meanwhile, investigations into learner agency and the effect of active learning techniques on oral reading abilities highlight the importance of providing educators with essential skills and pedagogical approaches to meet the diverse needs of Arabic language learners.

In conclusion, the synthesis of findings from these themes underscores the holistic approach needed to improve Arabic language education. By integrating innovative teaching strategies, addressing sociocultural and linguistic considerations, and prioritizing teacher training and professional development, stakeholders can work towards fostering a supportive and enriching learning environment that empowers students to become proficient and culturally competent Arabic language speakers.

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