

The Impacts of Bilingualism Learning Strategies in Science Education: A Systematic Literature Review

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DOI Link: <http://dx.doi.org/10.6007/IJARPED/v14-i3/26196>

Published Online: 18 August 2025

Abstract

Globalization has a profound effect on the way humans interact, share values and maintain their respective identities. The bilingualism approach allows the teaching and learning process to be carried out in two languages, namely the first language which is usually the mother tongue and the second language such as English. This study aims to conduct a systematic literature review (SLR) to identify the research trends and bilingualism learning strategies used in science education based on previous studies between 2021 and June 2025. This review utilizes two major databases namely Scopus and Web of Science (WoS) and is based on the PRISMA guidelines. A total of 25 articles were selected after going through a process of identification, screening, eligibility and quality assessment using the Mixed Method Appraisal Tool (MMAT). The results show that the qualitative approach is most dominantly used in previous studies while the translanguaging strategy is the most frequently applied approach in the classroom. The study findings also showed the use of bilingual strategies such as code switching, scaffolding and transcription played a role in improving students' scientific understanding, active engagement and confidence levels.

Keywords: Bilingualism, Dual Language, Translanguaging, Code-Switching, Transcription, Social Semiotic

Introduction

Globalization today is taking place on a very fast scale and is permeating various aspects of human life. Appadurai (1990) characterizes globalization as a process that is not easy otherwise it involves complex, overlapping and disjunctive cultural flows. The character of globalization is determined by the level of interconnectedness, integration, speed and scope between different economies, cultures, political systems, technologies and types of environments (Alkharafi & Alsabah, 2025). Modern globalization trends that emphasize openness, diversity and cross-border cooperation bring many benefits in economic, social and cultural aspects but also demand sensitivity to social justice, maintenance of cultural identity and equality in access to technology (Steger, 2017; UNESCO, 2009; Giddens, 2002; UNDP, 2020).

In the context of diverse linguistic and cultural backgrounds, globalization has had a profound effect on the way humans interact, share values and maintain their identities. This is because globalization facilitates the movement of people between countries for work, education, escape and international marriages creating ethnically and culturally diverse communities within a country (Sassen, 2021; Castles & Miller, 2009; UN DESA, 2021; Grohmann, 2023). Indeed, the world community is now increasingly exposed to different languages, customs and ways of life such that cultural diversity is no longer a border but a source of social and economic wealth.

Language is the main tool that allows community members from different backgrounds to interact, cooperate and understand each other. Language is not just a means of communication but a milestone to social harmony, cultural preservation and mind-building in a complex society. Language facilitates good communication but in certain circumstances can also be a barrier between two cultures (Divekar & Itankar, 2020). Therefore, individuals who master more than one language or known as bilinguals have a great advantage to fit in and compete on an international level. Nuri (2024) emphasized that it is not unusual in urban centers to meet people who frequently switch between languages either for professional purposes or daily social interactions.

Bilingualism refers to an individual's ability to use two languages with a certain level of proficiency. Bilingualism in the context of education refers to the use of two languages as a medium of teaching and learning either equally or predominantly to one of the languages (Baker & Wright, 2021). Wei and Garcia (2021) argue that bilingualism does not necessarily mean that an individual is fully fluent in both languages but refers to the dynamic ability to function in more than one language in various contexts. This global linguistic landscape has sparked widespread interest in bilingualism across various disciplines including linguistics, psychology, education and cultural studies (Pliatsikas et al., 2021).

Besides being an entry point to a people's culture, mastery of multiple languages can enhance cognitive abilities, promote equity in education, foster quality of identity and a sense of social inquiry and can help an individual to understand the values, practices and worldviews of other communities more deeply (Alisoy, 2024; Oral & Lund, 2024; Yuliasari & Sari, 2022). Linguistic skills can lead to stronger business relationships and more successful offers, making bilingual workers very valuable (Ibragimova & Nizametdinovna, 2024). The completion of language interests permeates individual, community and state aspects making it an important aspect in fostering an inclusive, progressive and united society.

Bilingualism in Science Education

Bilingualism is increasingly recognized as a necessity in the world of modern education to adapt to people from various language backgrounds. The rapid development of bilingual education around the world has encouraged the teaching of science in two languages. In the context of science education, the bilingualism approach allows the teaching and learning process to be carried out in two languages namely the first language which is usually the mother tongue and the second language such as English. According to Salaberri-Ramiro and Sánchez-Pérez (2022) various models of bilingualism in education have emerged since some time including Dual Language Immersion (DLI), Content and Language Integrated Learning (CLIL), Translanguaging and English as Medium of Instruction (EMI).

However, the implementation of bilingual approach in science education is not something easy as it involves various factors. The efficacy of bilingual education is influenced by the learner's language proficiency level, the teacher's willingness from a pedagogical aspect, the availability of appropriate teaching materials, the influence of the mother tongue and learner engagement (Galloway et al. 2020; Chavarria, 2021; Zoeller & Briceño, 2020; Madrid & Julius, 2020). Singh and Husaain's (2024) study found that teachers using more time to support Science teaching in two languages need to use specialized terminology related to science subjects in both languages while speaking or writing on the white board.

The bilingual approach in science education promotes the mastery of two or more languages as well as strengthens the understanding of scientific subjects to produce citizens who are more prepared to face global challenges and can maintain linguistic and cultural diversity and are designed to foster similarities between learners' native languages (Galloway et al., 2020; European Commission, 2020; San Isidro & Lasagabaster, 2018; Castro et al., 2025). Bilingual teaching methods do more good than harm by promoting multilingual identity through cultural integration by increasing biliteracy including in the mother tongue, supporting the process of cultural adaptation and cross-linguistic transfer (Song, 2022; Werblow et al., 2020; Pelila et al, 2025). The fusion between content and language learning allows learners to learn subject-specific knowledge and develop second language proficiency (Timotijevic et al., 2023).

The selection of an appropriate learning strategy is crucial as it can affect the learner's level of understanding, interest and achievement. Without a good strategy, knowledge delivery may not be able to meet the needs of learners who differ in terms of proficiency level, learning style and linguistic background. Learning strategies are considered a predictive factor towards student learning outcomes because effective learning strategies are always associated with producing successful students (Jamaluddin et al., 2021). Thus, understanding the motivation and engagement of learning to represent both the first language and the second language is important to support balanced bilingual development (Bai & Zang, 2025).

Purpose of Review

This systematic literature review (SLR) focuses on research related to bilingualism in science education. The SLR exercise in this study aims at identifying the research trends and learning strategies of bilingualism used in science education. The results of this study are also expected to contribute to the literature related to bilingualism in science education.

Research Questions

The research questions of this study are as follows:

1. How are bilingualism studies in science education distributed in terms of year of publication?
2. What is the research design used in previous studies?
3. What are the geographical areas covered in the previous studies?
4. What is the educational level of the study sample used in the previous studies?
5. What are the learning strategies of bilingualism in science education for previous studies?
6. What is the role of learning strategies used to support bilingualism in science education for the previous studies?

Methodology

SLR helps to map and assess existing knowledge and gaps related to specific issues to develop a foundation for that knowledge (Mengist et al., 2020). The use of SLR can provide a comprehensive overview of past studies to understand the landscape of bilingual inquiry in science education. SLR can help to see the phenomena that occur around keywords clearly and get some literature that fulfils the objectives of the study (Abdul Rahman et al., 2017). In addition, the SLR method includes the year of the study, background, study problem, study methods and findings and uses a systematic search to generate the necessary elements in the study (Kamal & Hussin, 2020).

The implementation process needs to be carefully designed before embarking on a real literature search. SLR is a research methodology to collect, identify and critically analyse existing research studies such as articles, trial proceedings, books and dissertations through a systematic procedure (Pati & Lorusso, 2017). According to Sauer and Seuring (2023) there are six steps in the implementation of SLR, namely (i) defining the review problem (ii) determining the characteristics required for the primary review (iii) retrieving potentially relevant literature (iv) selecting relevant literature (v) synthesizing the literature and (vi) reporting the results. When the SLR procedure can be implemented correctly and has minimum error, the review can provide reliable findings and solid conclusions to help decision makers and scientific practitioners to act appropriately (Antman et al., 1992; Oxman & Guyatt, 1993; Tranfield et al., 2003).

This review uses the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to achieve the stated objectives. The use of the PRISMA method can assist reviewers in determining the required review based on the review problem (Jamaluddin et al., 2020). This method provides a thorough process for selecting relevant and quality articles, facilitates detailed examination of the various views of researchers and authors and can address specific issues and open up space for finding research gaps (Hoque et al., 2022). Guidelines PRISMA consists of four levels, namely identification, screening, eligibility and article entry in SLR studies (Margot & Kettle, 2019). The PRISMA flow diagram guideline has been used to determine bilingual research in science education that matches the reviewer's preferences.

Identification Phase

Following the PRISMA guidelines, the first step of this protocol is the identification phase. SCOPUS and Web of Science (WoS) databases were used to create searches based on the selected keywords. These two databases were used because they include all journal articles from various different links (Nageswari & Siti Mistima, 2022). The related keywords were about bilingual and Science education and words synonymous with it. The keywords used by the reviewer along with the Boolean search in searching the SCOPUS and WoS sites were ("bilingual education" OR "dual language" OR "translanguaging" OR "multilingual") AND ("science education" OR "science teaching" OR "science learning" OR "science classroom"). From this phase, the reviewer has obtained 661 articles related to the scope of the review.

Screening Phase

The selection of articles in the SCOPUS and WOS databases is based on predetermined criteria, namely year of publication, type of reference material and language. The criteria for

year of publication are 2021 to 2025, which is within the most recent five-year period. This is to ensure that the articles selected for SLR purposes discuss current issues in the use of bilingualism in Science education. The second criterion that has been set involves the type of reference material. Only journal articles were selected and excluded other types of reference materials such as books, proceedings, theses and trials. Journal articles are reference materials that have complete and detailed reporting (Hamzah & Hidayat, 2022). All articles selected were in English only. Table 1 shows the article selection and rejection criteria for this study.

Table 1

Article acceptance and rejection criteria

Criteria	Acceptance	Rejection
Year of publication	Publishing from 2021 up to 2025	Issuance before 2021
Type of material	Journal articles	Thesis, proceedings and books
Languages	English	Other than English

After the screening process based on the acceptance criteria, 261 articles were selected to go through the next phase. A total of 178 articles were removed for not having full text and only 83 articles were eligible for the next stage.

Eligibility Phase

The third stage is the eligibility phase where the selected articles will go through a more in-depth analysis to understand the themes of the research and gain information about the scope of bilingual studies in Science education. The screening process is done in the feasibility phase to ensure all the selected articles are relevant and can be used by the reviewers (Azemi & Hamzah, 2024). In this context, assessment is a process that screens articles, titles and abstracts of studies as well as methodologies, decisions, discussions and conclusions as necessary. The analysis has excluded 5 articles because they did not focus on the use of bilingualism in science education. Next, 46 articles have been excluded because they do not provide related to teaching sessions and teaching of science classrooms using a bilingual approach. After the eligibility process, 32 articles have gone through the next process, namely quality assessment. Figure 1 shows the selection formula of the articles used in this study.

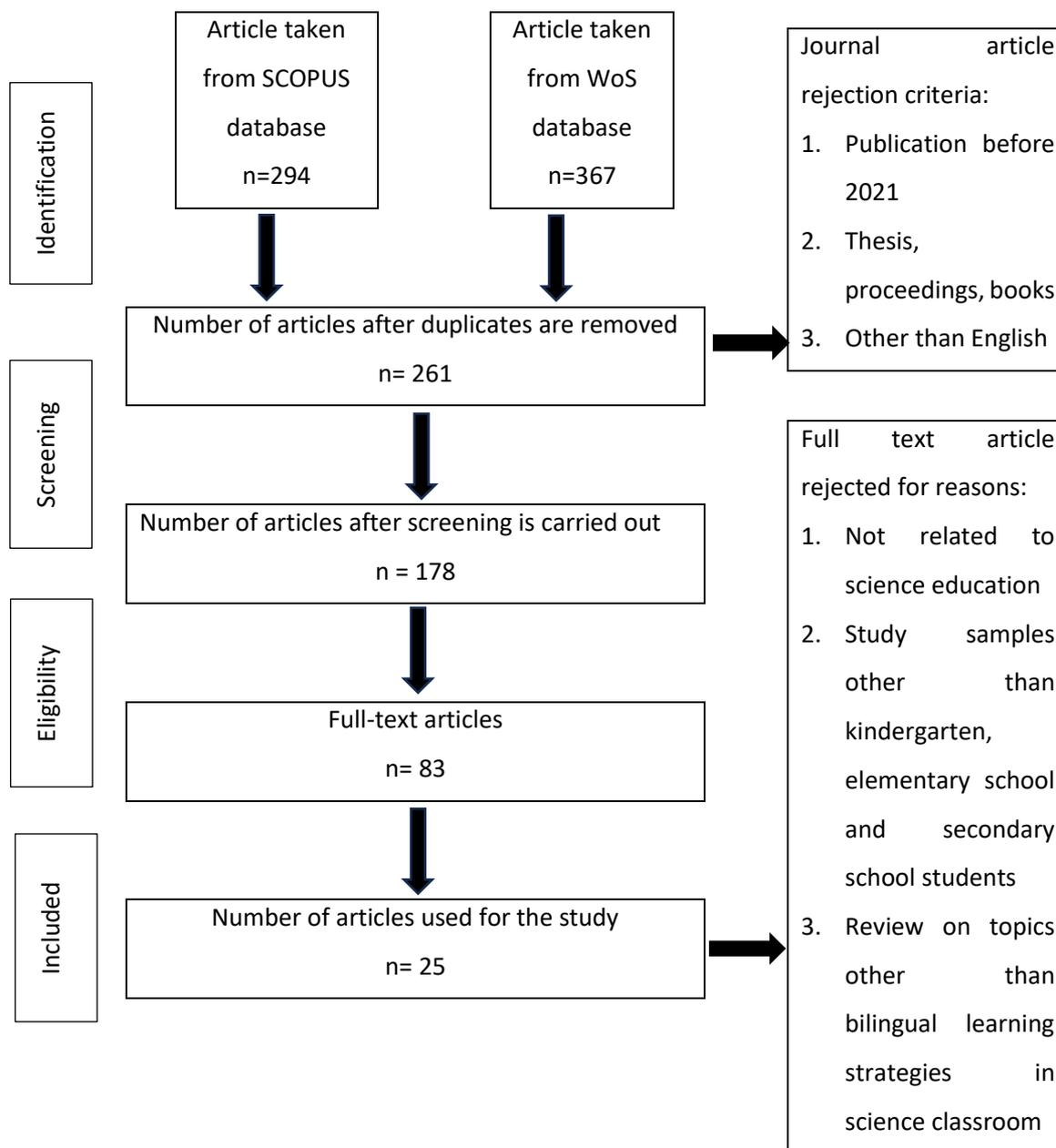


Figure 1: PRISMA flow diagram image

Quality Assessment

At the feasibility stage, the reviewers have made an assessment of the trustworthiness of the articles using the Mixed Method Appraisal Tool (MMAT). The quality assessment process of the selected articles can reduce bias and help the reviewers detect weaknesses in the study methods and data for independent studies. The selection of MMAT is suitable for use in the assessment process because the selected articles to assess the selected articles in consist of various research designs, namely quantitative, qualitative and mixed methods (Hamzah et al, 2022). Based on Hong et al., (2018) the first step assessed by the reviewers is based on two general criteria as stated in Table 2.

Table 2

Article quality assessment

Article Quality Assessment Criteria (General)	Y	N	C
Is the research question stated initially?			
Is the data obtained able to answer the stated research question?			
Decision	/	X	X

Based on the quality assessment of the selected articles, the reviewer concentrated the data extraction process from the three main parts of the article such as abstract, decision and discussion to identify the teaching strategies of bilingualism in Science education. If there is a need, the reviewer also reads other parts of the article to get relevant data. The extracted data were then translated into table form according to the categories i.e. author's name, year of publication and bilingualism teaching strategies used in science degree rooms in freelance studies. After 25 articles were selected for analysis after the formulation of the quality assessment process was carried out.

Data Analysis

Each selected freelance review article has been extracted to answer the problem of this SLR study. The reviewer used thematic qualitative analysis of the selected articles that have different study designs because qualitative synthesis techniques can assess the pattern of findings based on the similarities and links between the findings to be studied (Hamzah et al., 2022). Article datasets that have similarities and interrelationships have been combined into one dataset and given appropriate themes (Azemi & Hamzah, 2024). Table 3 shows the list of articles selected along with author name, year of publication and review title.

Table 3

List of articles selected for review

No	Author & Year	Title
1	Cheung & Tai (2024)	"Did you watch the Disney parade?" pedagogical translanguaging for evoking students' perezhivanie to integrate representations in linguistically diverse science classroom
2	Ganesan & Morales (2024)	A science teacher's experiences when fostering intercultural competence among students in multilingual classrooms: a narrative study
3	Nikula et al., (2024)	Multimodal practices of unpacking and repacking subject-specific knowledge in CLIL physics and chemistry lessons
4	Wilmes (2021)	Interaction rituals, emotions, and early childhood science: digital microscopes and collective joy in a multilingual classroom
5	Lemmi & Pérez (2024)	Translanguaging in elementary science
6	Salloum et al., (2025)	Syrian refugee youths' science learning in a "dialogic" third space: Pushing boundaries in the Lebanese educational system through translanguaging
7	Cassano & Paciga (2024)	Guided Drawing with Preschool Dual Language Learners in Head Start: Building Science Vocabulary and Content Knowledge

8	Vilakazi et al., (2024)	Multilingual Education in Life Sciences: Teachers' and Learners' Beliefs About Code-Switching
9	Cheung et al., (2024)	'Swirling' around translanguaging spaces of nature of science in multilingual classrooms
10	Karlsson (2025)	An orchestra of semiotic resources in a translanguaging science classroom
11	Charamba E. (2023)	Translanguaging as bona fide practice in a multilingual South African science classroom
12	Wilmes & Siry (2024)	Engaging with materials and the body: young plurilingual children's resource-rich interactions in science investigations
13	Uddling & Reath Warren (2023)	A newcomer's spontaneous translanguaging in lower-secondary physics education
14	Swart et al., (2024)	Physical Science Teachers' Use of Reading Strategies in a South African Context
15	Tai (2022)	Translanguaging as Inclusive Pedagogical Practices in English-Medium Instruction Science and Mathematics Classrooms for Linguistically and Culturally Diverse Students
16	Siry et al., (2025)	Young children's translanguaging as emergent in and through open-ended science pedagogies
17	Setyaningrum et al., (2022)	Translanguaging as a Scaffolded Practice in a Primary School Content and Language Integrated Learning Context During the COVID-19 Pandemic
18	Pierson et al., (2021)	Scientific modelling and translanguaging: A multilingual and multimodal approach to support science learning and engagement
19	Navarro Martell (2022)	Ciencias bilingües: How dual language teachers cultivate equity in dual language classrooms
20	Tyler (2021)	Transcribing whole-body sense-making by non-dominant students in multilingual classrooms
21	Rumper et al., (2021)	Portrait of early science education in majority dual language learner classrooms: Where do we start?
22	Pun & Tai (2021)	Doing science through translanguaging: a study of translanguaging practices in secondary English as a medium of instruction science laboratory sessions.
23	Book & Tandberg (2024)	Identity texts in science for multilingual students: discovering resources with social semiotics
24	Roth et al., (2022)	Content and Language Integrated Scientific Modelling: A Novel Approach to Model Learning
25	Set (2023)	The Constraints of Monolingual Language Policy and Heteroglossic Practices as a Vehicle for Linguistic Justice

Study Findings

This SLR study was conducted to get an overview of the previous studies on the implementation of bilingualism in science education from the aspects of year of publication, research design, study area, educational level of the study sample, learning strategies of bilingualism and its role in the science classroom. The reviewer uses tables and graphs to give a clearer picture of the study findings.

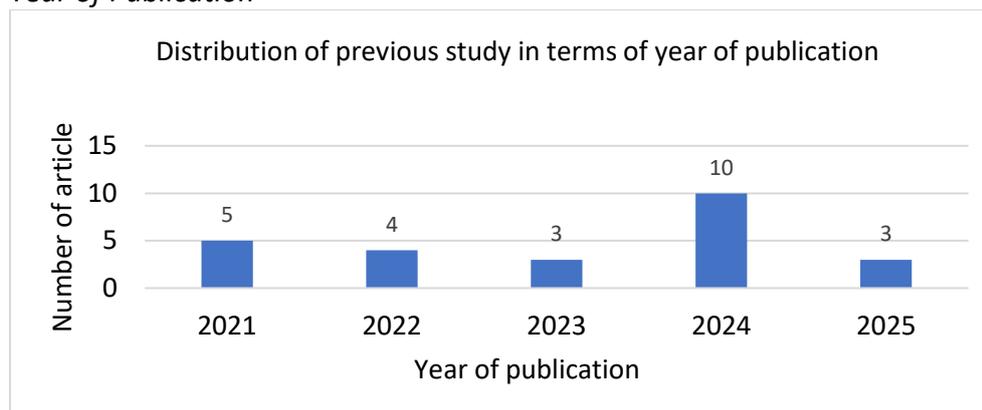
Year of Publication

Figure 2: Year of Publication

The first research question of this study emphasizes the distribution of previous studies by year of publication. Based on the overall findings shown in Figure 2, the distribution of previous studies by year of publication is not uniform. The publication of previous studies related to bilingualism in science education is highest in 2024 (N=10 or 40%), followed by 2021 (N=5 or 20%) and 2022 (N=4 or 16%). The number of studies published in 2023 and 2025 is the same at 3 studies.

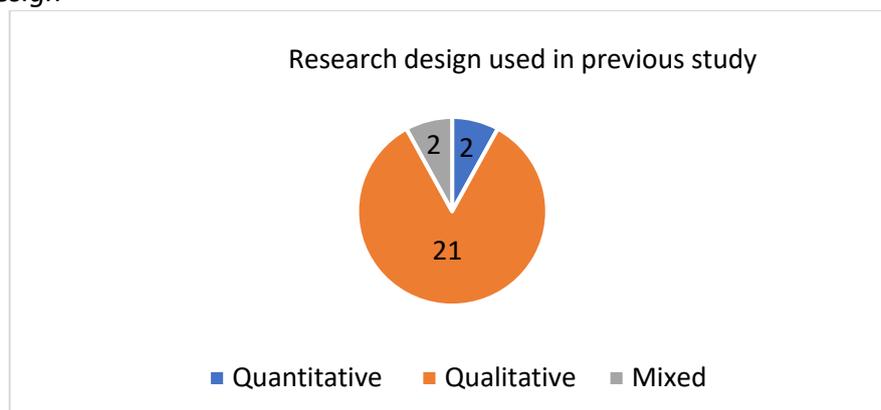
Research Design

Figure 3: Research design

The second research question is what research design is used in previous studies. Based on Figure 3, previous studies for bilingualism in science education use three types of research designs namely quantitative, qualitative and combined (mixed-method). The findings show that the majority of the previous studies were conducted based on a qualitative approach (N=21 or 84%). Based on the analysis of the qualitative approach, it was found that three designs were used in the previous study namely case study (N=10 or 48%), ethnography (N=10 or 48%) and phenomenology (N=1 or 4%). Although there are other approaches used in the previous study such as quantitative approach (N=2 or 4%) and combined method (N=2 or 4%) but the number is very low.

Geographical Area

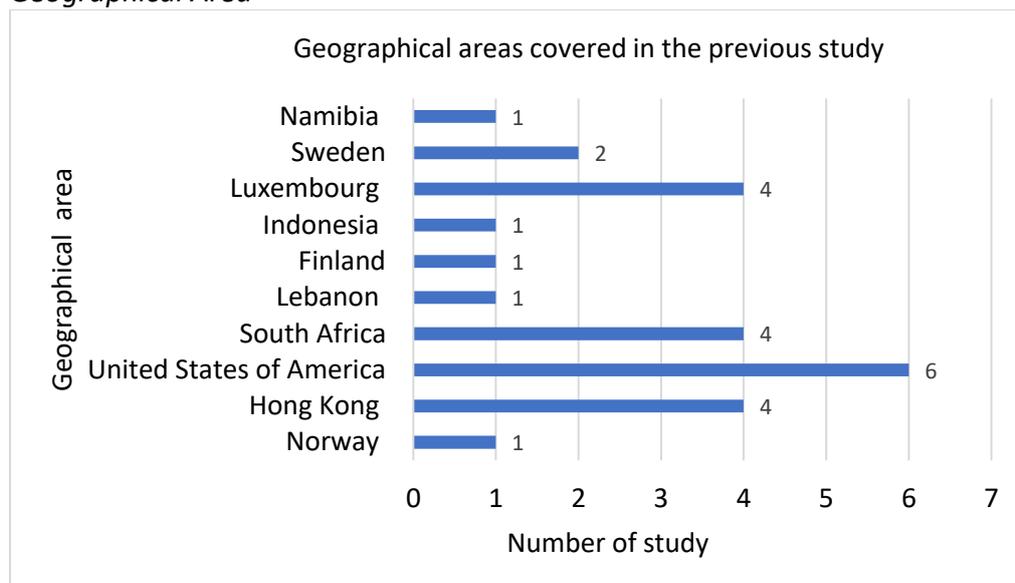


Figure 4: Study area

The third question involves the country selected as the study area. Based on Figure 4, the study areas were countries from the Americas, Africa and Asia. The most studies were conducted in the United States of America (N=6 or 24%) and followed by the countries of South Africa (N=4 or 16%), Hong Kong (N=4 or 16%), Luxembourg (N=4 or 16%). Studies on bilingualism in science education were also conducted in Sweden (N=2 or 8%). One study was conducted in Namibia, Indonesia, Finland, Lebanon and Norway.

Education Level of Study Sample

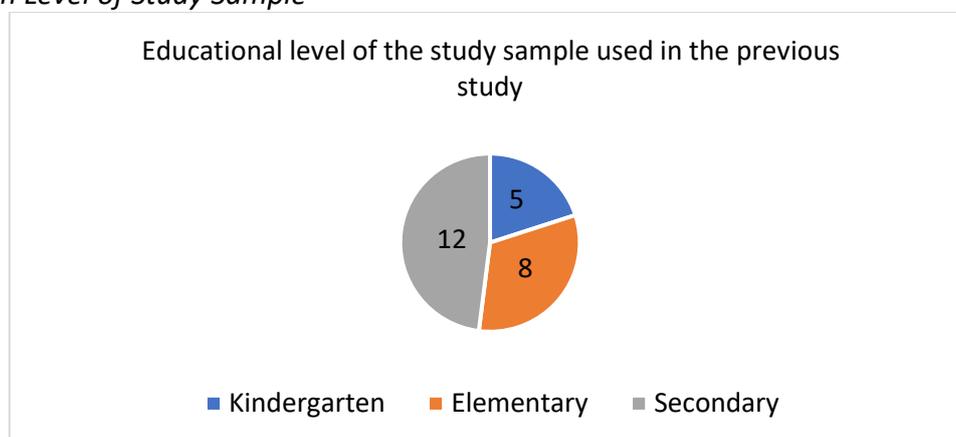


Figure 5: Education level of the study sample

The third research question involves the educational level of the previous study sample. The study sample in the context of this issue refers to students only. Based on Figure 5, students studying in secondary schools (N=12 or 48%) were most frequently used as the independent study sample. The previous study also selected low number of elementary students (N=8 or 32%) and kindergarten (N=5 or 19%) as samples in the study of bilingualism in science education.

Learning Strategies for Bilingualism in Science Education

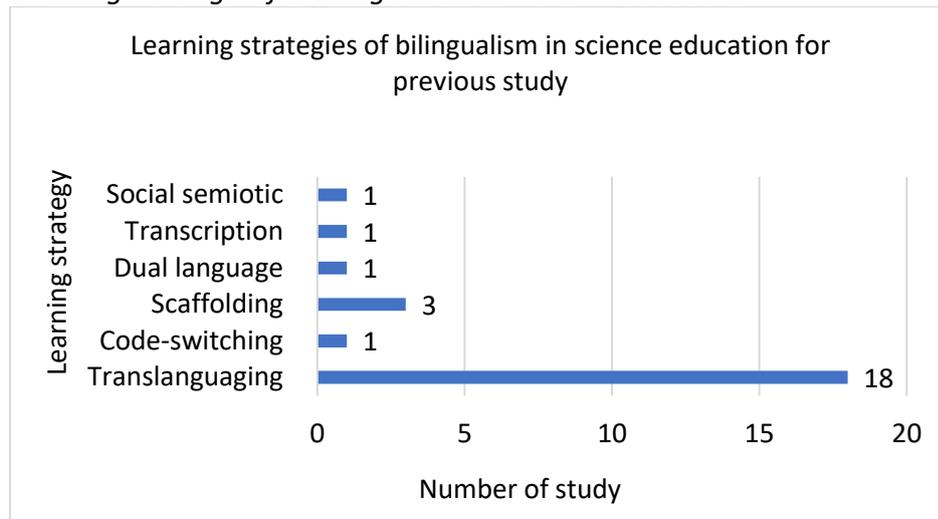


Figure 6: Learning strategies of bilingualism in science education

The next research question is what are the approaches used to support Science learning in bilingualism studies. Based on Figure 6, there are six bilingualism strategies used in science classroom. The most widely used bilingualism approach is translanguaging (N=18 or 72%) and followed by scaffolding in the form of painting, visual and reading skills (N=3 or 12%). Social semiotic, transcription, bilingual and code-switching approaches are also used to support Science learning of learners who have diverse linguistic backgrounds.

The Role of Bilingualism Learning Strategy In Science Education

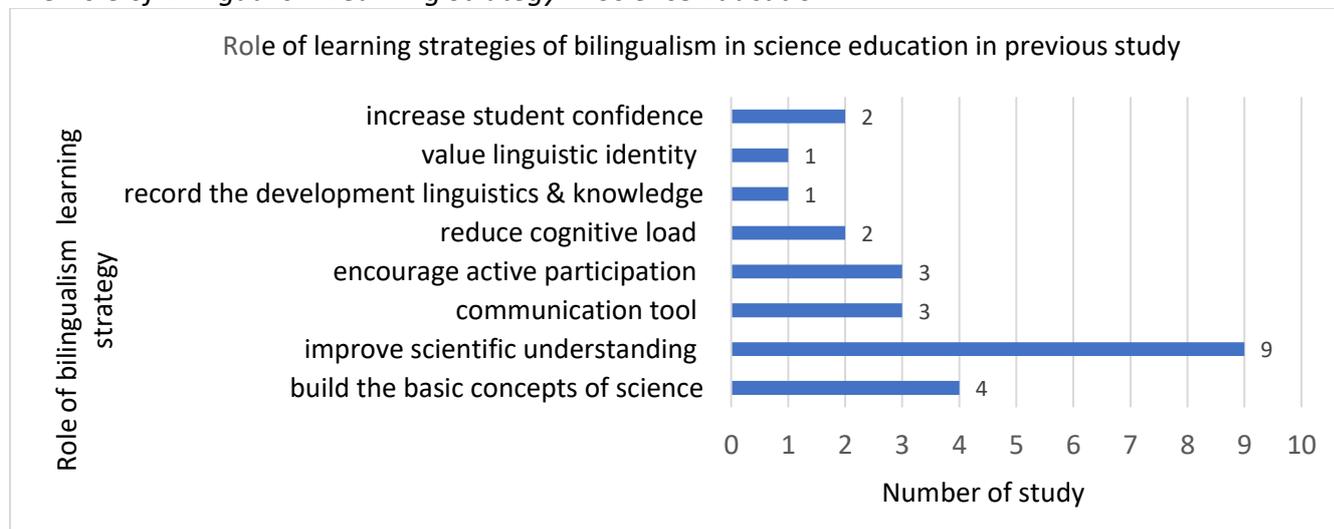


Figure 7: The role of bilingualism strategy in science education

The last research question is to identify the role of bilingualism approach in science education for previous study. Based on Figure 7, there are eight main themes that show the role of the learning approach used. The bilingualism strategy can improve students' scientific understanding (N=9 or 36%), build basic concepts of science (N=4 or 16%), promote active engagement (N=3 or 12%) and as a communication tool for social interaction in the classroom (N=3 or 12%). In addition, the approach chosen to support the implementation of bilingualism can also increase learner confidence (N=2 or 8%), reduce cognitive load (N=2 or 8%), can

respect learner linguistic identity (N=1 or 4%) and can simultaneously record learner linguistic and knowledge development (N=1 or 4%).

Discussion

The implementation of this SLR study was to identify teacher learning strategies at a global level to support science learning in a classroom consisting of students with various linguistic backgrounds. The study findings show that the publication of articles related to the use of bilingualism in Science education has decreased after the COVID-19 pandemic. School-based research is dealing with the lasting effects of Covid-19 due to school closures, increased use of technology in teaching and constraints from the aspect of staffing and decisions taken by stakeholders (Carter et al., 2024). The number of article publications shows a positive development in 2024 by showing a significant increase. In the context of this study, the articles selected for 2025 are in low numbers because the data of this study was taken until the beginning of June only.

Based on the findings, studies of bilingualism in Science education have been carried out in four continents namely the Americas (Lemmi & Pérez, 2024; Cassano & Paciga, 2024; Pierson et al., 2021; Navarro Martell, 2022; Rumper et al., 2021), Europe (Nikula et al., 2024; Wilmes, 2021; Karlsson, 2025; Wilmes & Siry, 2024; Uddling & Reath Warren, 2023; Siry et al., 2025; Book & Tandberg, 2024; Roth et al., 2022), Africa (Ganesan & Morales, 2024; Vilakazi et al., 2024, Charamba, 2023; Swart et al., 2024; Tyler, 2021; Set, 2023) and Asia (Cheung & Tai, 2024; Salloum et al., 2025; Cheung et al., 2024; Tai, 2022; Setyaningrum et al., 2022; Pun & Tai, 2021). The use of bilingualism in science education in the study area emphasizes the mastery of scientific skills and nurtures the diversity of students' language backgrounds whether as native speakers or minorities.

Qualitative approaches are used more frequently in previous studies compared to quantitative and combined designs. The main strength of the qualitative approach is that the description can be carried out in depth and the written description can usually produce sufficient details to allow the reader to understand the features of the study (Devetak et al., 2010). Qualitative design allows the reviewer to directly see the behaviour of the study participants and how bilingual learning strategies are used within the scope of a classroom that is rich with diversity of cultures and languages. The approach allows the reviewer to achieve the objectives of the study and make generalizations that can represent the atmosphere of bilingual learning in science education (Prince, 2023). In the context of this SLR study, a quantitative approach was used by a previous study reviewer to determine the relationship between teacher and learner beliefs and code-switching learning strategies in Life Science subjects (Vilakazi et al., 2024). The combined approach also allows reviewers in previous studies to gain insight into studies that may not be fully understood using qualitative and quantitative alone (Dawadi et al., 2021).

The most frequently used study sample is students who are in secondary school i.e. from grade 7 to grade 11. This is because secondary school students are at the appropriate cognitive stage for pedagogy-related research such as bilingualism learning strategies for learning Science which basically refers to the overall concepts related to physics, chemistry and biology (Kurt, 2021). The selection of secondary school students as the study sample is relevant to the study of Stuckey et al. (2013) by stating that science learning at the secondary

school level is rather balancing especially with regard to physical and chemical learning. Children either at the kindergarten or lower school level being selected as the sample in a previous study is a progressive and encouraging finding for long-term implications. This is because early exposure to different languages and basic concepts can shape interest, attitude and motivation in science as children have a high sense of curiosity (İlhan & Tosun, 2016).

Translanguaging is widely used as a learning strategy in science classrooms consisting of students from different background of life and languages. Translanguaging is a linguistic application related to cultural practices using the learner's first and second languages to enhance understanding and communication (Kim & Kim, 2024) in line with the findings in this SLR. Translation from the second language to the mother tongue through the translanguaging approach can reduce cognitive load as well as avoid confusion for science terms used in the classroom (Tai, 2022; Setyaningrum et al., 2022). The effect is that students feel more confident to communicate and engage actively to make science classroom learning more meaningful (Wilmes, 2021; Charamba, 2023; Salloum et al., 2025; Wilmes & Siry, 2024; Karlsson, 2025). This conducive science learning atmosphere can build the fundamental concepts of science and strengthen scientific understanding among students (Lemi et al., 2021; Cheung & Tai, 2024; Nikula et al., 2024; Swart et al., 2024; Pierson et al., 2024).

The 50:50 model bilingual learning strategy is used in science classrooms in the United States to provide support to the rigorous learning of science to all students. According to Navarro Martell (2022), the bilingual approach creates a democratic learning space where all students have the courage and equal opportunities to take part in science learning. The bilingual approach combined with hands-on activities such as guided painting are more effective as students can actively participate in learning and make the learning process more meaningful (Cassano & Paciga, 2024; Yilmaz et al., 2024; Swart et al., 2024) in improving vocabulary and basic science concepts. Code-switching strategies referring to the exchange between two separate languages in the same paragraph allow teachers to give instructions with the class so that students can understand learning materials and instructions clearly (Vilakazi et al., 2024). Assignments through social approaches such as painting, writing and oral description as well as using different sources can help strengthen students' scientific knowledge (Book & Tandberg, 2024). The transcription approach by generating comics is an innovation that allows teachers to simultaneously record linguistic knowledge and learner knowledge (Tyle, 2021).

Conclusion

Bilingualism in science education not only plays a role as a language approach but also an educational strategy that can enrich scientific learning and open wider opportunities for students to interact in a global community. The bilingual approach in science education requires careful design including the provision of bilingual teaching aids, the use of scientific terms in two languages as well as the ability of the teacher to be a facilitator who determines the goals of interaction in the classroom using appropriate language strategies. Learning strategies from freelance studies such as translanguaging, code-switching, scaffolding (painting and reading proficiency), transcription and social semiotics proven to help students build and understand science concepts with more depth from cognitive, affective, social, metacognitive, linguistic and psychomotor aspects. The support of all parties including layers

of society, educators and stakeholders and decision makers is needed to ensure the stability of the bilingualism approach in science education.

Study Limits

This SLR study only uses two main databases namely Scopus and WoS only. This limitation may lead to potential exclusion of relevant articles from other databases. The publishing period of the selected journals is from 2021 to 06 June 2025. This is to ensure the quality of information obtained for a constantly evolving field of study such as bilingualism in science education. The keywords used in the search for articles are limited to translanguaging and dual language programmes so that it can lead to the search for articles with relevant content.

Recommendations for Future Study

The main proposal of the forthcoming study is to examine the efficacy of professional training as a preparation of teachers who teach bilingually in science education. This is because, studies that assess training modules that are contextual and practical are needed in order to identify the objectives of teacher professional development programs in helping teachers to master aspects of pedagogy, instructional design, use of bilingual teaching aids and communication strategies such as code- switching and translanguaging.

In the increasingly complex and competitive world of education, the integration of technology in teacher professional training courses has become an urgent need. This is because teachers not only need to master scientific and language content but also have a pedagogical approach that is flexible, dynamic and in line with the current generation of students. Therefore, future studies that can examine the extent to which existing professional training courses integrate technological and bilingual elements in training approaches are urgently needed to improve the quality and effectiveness of science teaching, especially those using bilingual approaches.

Acknowledgement

I would like express my deepest sense of gratitude to my supervisor, Dr Siti Nur Diyana Mahmud for the guidance and help throughout the process of completing this SLR.

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