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Google Translate-Assisted Translanguaging Practice To Enhance Primary School Students'ESL Meaning Making In Reading

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ABSTRACT

This study addresses the persistent decline in reading proficiency among primary school students in rural Malaysia, focusing on enhancing English as a Second Language (ESL) reading skills. The purpose is to investigate the effects of integrating AI - assisted digital translanguaging, specifically through Google Translate, on students' reading comprehension and vocabulary development. A mixed-method case study design was employed, involving four Year 6 ESL students assessed at an intermediate language proficiency level. Data were collected through pre- and post-tests, classroom observations, interviews, and document analysis, and analyzed thematically. Results showed improvement in reading comprehension and vocabulary scores, with increased student motivation and engagement. However, challenges such as translation inaccuracies, overreliance on AI, and varied use of metacognitive strategies were evident, highlighting the importance of teacher mediation. The study concludes that Google Translate -assisted translanguaging can effectively support ESL reading development when balanced with pedagogical guidance, fostering learner autonomy and digital literacy. Recommendations include targeted teacher training and structured instructional strategies to optimize AI integration in multilingual classrooms.

1. Introduction

The Fourth Industrial Revolution (4IR) represents a key transformative phase characterized by the convergence of digital, physical, and biological technologies that are reshaping industries and societies globally. Within this landscape, multilingualism and translingualism have become critical competencies for effective global collaboration and market participation. Multilingualism—the ability to use multiple languages—and translingualism—the fluid movement across languages—are increasingly vital for facilitating communication, collaboration, and knowledge exchange across

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borders [1] [2]. As businesses and educational institutions operate in more globalized settings, proficiency in multiple languages and the capacity to negotiate meaning across linguistic boundaries are essential for maximizing opportunities and fostering inclusive participation in the global economy [3] [4]. Aligned with the goals of Industry 4.0 to prepare a diverse, multilingual workforce capable of navigating globalized, technologically advanced environments, the United Nations' Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), emphasize inclusive and equitable quality education and lifelong learning opportunities for all [5]. SDG 4 also underscore the importance of inclusive, equitable quality education, emphasizing mother tongue-based multilingual education (MTB-MLE) as a means to improve learners' comprehension, engagement, and critical thinking skills [6].

Recent studies also highlight translanguaging's potential to enhance intercultural communication among ESL learners by leveraging linguistic diversity [7] and to improve teaching and learning efficiency through multimodal devices that stimulate students' senses [8] [9]. In Malaysia, the *Memartabatkan Bahasa Malaysia dan Memperkukuhkan Bahasa Inggeris* (MBBMMBBI) policy stresses strengthening proficiency in both Malay and English, which supports the integration of artificial intelligence (AI) tools such as Google Translate within digital translanguaging practices aimed at enhancing meaning-making in ESL reading classrooms [10] [11]. This policy is implemented through curriculum reforms, increased English instruction hours, teacher training, and blended learning models. Malaysia's dual language programs and vernacular schools further support Mandarin, Tamil, and other indigenous languages, fostering a multilingual environment that prepares students for participation in a globalized world [12]. Despite these efforts, challenges remain, including disparities in language proficiency, resource allocation, and the need for effective digital tools to support language learning [13]. Digital translanguaging practices—using digital tools to fluidly navigate and make meaning across languages—have emerged as promising approaches to enhance reading and comprehension skills among Malaysian language learners.

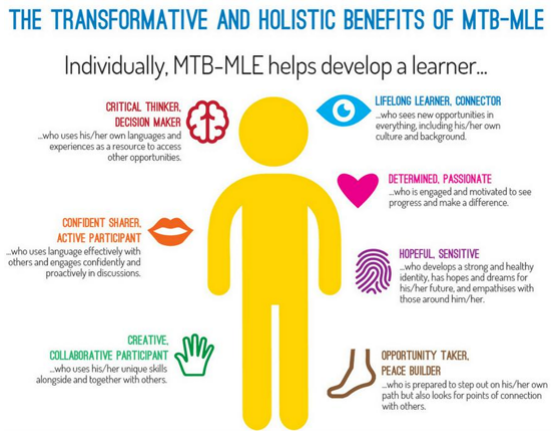


Fig 1. MTB-MLE

Malaysia's rich linguistic diversity includes Malays (58.1%), Chinese (22.4%), Indians (6.5%), and indigenous Bumiputera groups, comprising approximately 137 living languages [14] [15]. Despite this richness, Malaysian education primarily focuses on Malay, English, Mandarin, and Tamil. Malay is the main medium in public schools, while private and international schools often use English [16]. Over the past two decades, language and education policies have evolved under globalization, employability, and national identity concerns, but indigenous and minority languages remain largely overlooked. However, declining reading proficiency among Malaysian students is a significant concern; the 2022 PISA report documents that only 42% of 15-year-olds met the minimum reading

proficiency threshold, indicating urgent needs for intervention [17]. Most sixteen-year-olds now attain only basic reading proficiency, able to identify simple information and main ideas but lacking skills to draw deeper connections or critically evaluate texts [18]. Few students reach advanced literacy levels, while many remain at or below baseline, unable to progress beyond basic comprehension. This decline threatens educational attainment and future employability, with experts warning it could undermine efforts to strengthen critical thinking and problem-solving skills among Malaysian youth [17].

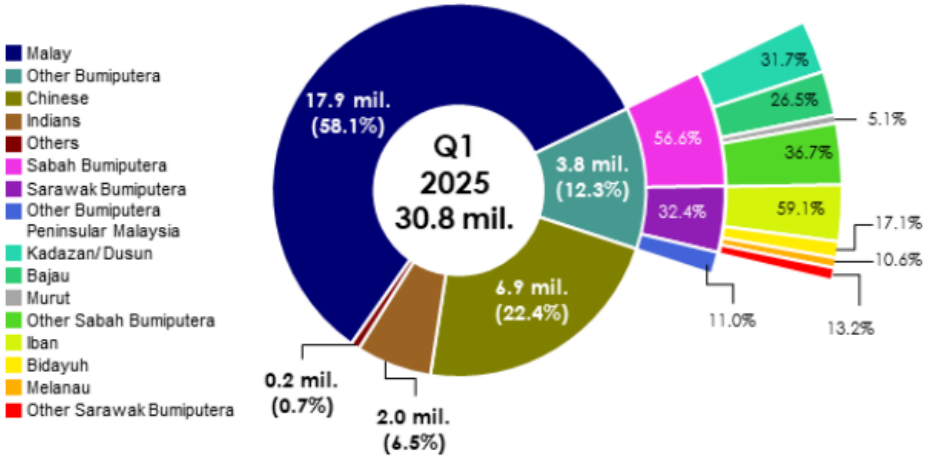


Fig 2. Race Population in Malaysia in the fourth quarter 2025 [14]

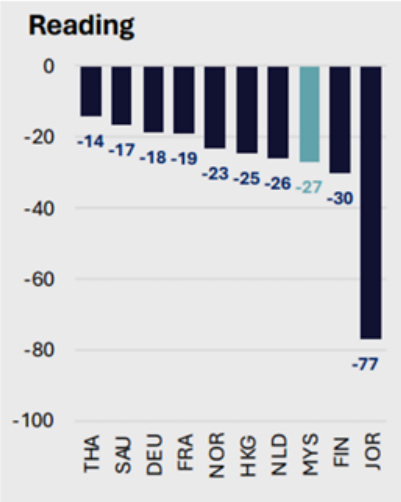


Fig. 3 Average Malaysia PISA reading score from 2012 to 2022

In response, Google Translate- assisted translanguaging practices leveraging tools offer flexible scaffolding for vocabulary acquisition, comprehension support, and metacognitive strategy development such as planning and self-monitoring [19] [20]. While beneficial, issues such as cognitive offloading and automation bias caution against overreliance, underscoringthe need for balanced pedagogical implementation.

Research Purpose and Questions

The primary purpose of this study is to investigate AI-assisted translanguaging via Google Translate to enhance reading comprehension among rural Malaysian Year 6 ESL students (CEFR Band 3, n=4) at the participated school —addressing PISA-declining reading proficiency amid infrastructural inequities. Unlike prior urban/secondary studies confirming general translanguaging benefits, this rural primary case advances by: (1) validating phased implementation yielding 42% comprehension gains despite AI inaccuracies; (2) identifying context-specific challenges like cultural translation mismatches and overreliance; (3) proposing "critical translanguaging"—teacher-mediated metacognitive prompting—absent in existing frameworks.

The research questions are as follows:

1. How does the integration of digital translanguaging practices, using Google Translate, enhances the reading comprehension skills of primary school students?
2. What are the challenges associated with implementing digital translanguaging in ESL classrooms in Malaysian primary schools?
3. What are the pupils' perceptions towards the translanguaging approach and teachers using metacognition and translanguaging in reading skills?

2. Literature Review

2.1 Theories Beneath Translanguaging Practice In ESL

Translanguaging Theory conceptualizes translanguaging as a dynamic, integrative practice that involves the fluid use of a learner's entire linguistic repertoire to construct meaning and develop language skills [21]. This theory challenges traditional monolingual approaches by emphasizing multilingual learners' agency and autonomy through the simultaneous use of multiple languages. AI tools like Google Translate operationalize translanguaging by providing real-time cross-linguistic support, enabling learners to access and integrate diverse language resources seamlessly for enhanced comprehension [22]. This aligns with translanguaging's core assertion that linguistic boundaries are socially constructed and that empowering learners to utilize their full repertoire fosters deeper understanding and academic success [23].

The Social Learning Theory complements translanguaging by highlighting the social and collaborative dimensions of learning [24]. It emphasizes that learning occurs through observation, imitation, modelling, and interaction with peers and teachers. In translanguaging classrooms, social learning facilitates scaffolding and co-construction of knowledge, where learners negotiate meaning by dynamically switching and blending languages during collaborative reading and discussion activities [9]. However, AI translation limitations, such as a lack of contextual sensitivity and potential inaccuracies, necessitate critical peer and teacher mediation to avoid misunderstandings and reinforce accurate language use [25].

The Cognitive Theory of Multimedia Learning focuses on dual-channel information processing, where learners engage verbal and visual cognitive pathways concurrently [26]. When students use AI-assisted tools like Google Translate, they receive multimodal input—text and its translated form, images or phonetic cues—enhancing comprehension through a top-down reading approach [27]. Learners activate prior knowledge, generate predictions, and monitor their understanding, supported by AI's scaffolding role that reduces cognitive load, making complex texts more accessible.

Finally, cognitive constructivist learning theory, drawing from Piaget's principles, emphasizes that learners actively construct knowledge by assimilating new information into existing mental schemas

through individual cognitive processes [28] [29]. In the realm of AI- assisted translanguaging, tools like Google Translate support this process by providing immediate, individualized access to multilingual input, enabling learners to independently decode unfamiliar vocabulary, syntax, and meaning. The multimodal features of AI tools—such as text, audio, and visual supports—align with cognitive constructivist principles by reducing cognitive load and catering to diverse learning preferences [27]. This scaffolding allows learners to build coherent mental models as they integrate new linguistic information with prior knowledge, thereby enhancing comprehension and retention. Nevertheless, cognitive constructivism also cautions against passive reliance on AI, highlighting the need for learners to critically evaluate and process AI-generated translations to achieve deeper understanding and avoid superficial learning [25].

Socio-constructivist learning theory, rooted in Vygotsky's work, posits that knowledge is constructed through social interaction, collaboration, and shared meaning-making within a community [30]. In the context of Google Translate- assisted translanguaging, this perspective highlights how Google Translate can serve as mediating artifacts that facilitate collaborative learning and peer scaffolding in multilingual environments. When students use Google Translate in group reading or problem-solving activities, they negotiate meaning, co-construct understanding, and support each other's language development [31]. This collaborative process not only enhances comprehension but also fosters metalinguistic awareness, as learners reflect on language choices and cultural nuances together [32]. Socio-constructivist approaches are particularly effective in digital translanguaging spaces, where learners can engage in dialogue, share resources, and build knowledge collectively, leveraging the affordances of AI to bridge linguistic gaps [34]. However, the success of such approaches depends on critical engagement and teacher mediation to ensure that AI-generated translations are contextually appropriate and that learners are not overly reliant on technology.

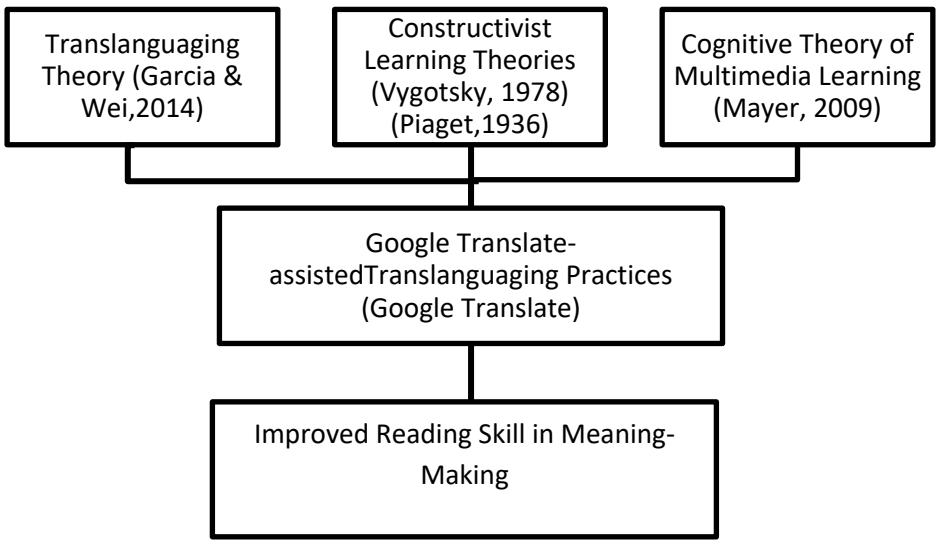


Fig. 4 Conceptual Framework

2.2 Translanguaging in Meaning-Making Reading

Translanguaging departs from code-switching by advocating purpose-driven multilingual blending that enables cognitive flexibility, allowing learners to utilize their entire repertoire for

meaning-making rather than episodic switches, reflecting authentic competence in Malaysia's diverse classrooms and positioning it as culturally responsive pedagogy [35] [23]. AI integration via Google Translate adds a digital dimension, providing real-time lexical/syntactic support to reduce reading barriers, enabling fluid L1-target language shifts to clarify vocabulary/sentences and scaffold comprehension [23]. Google Translate's neural models deliver context-sensitive, human-like translations that minimize cognitive load per Mayer (2009), fostering metacognitive strategies (planning/monitoring/evaluating) aligned with top-down reading models leveraging prior knowledge/contextual cues [36] [37].

This approach enhances higher-order comprehension in multilingual settings, with empirical benefits including multimodal scaffolding for improved reading, boosted motivation/confidence, and plurilingual flexibility [38]. However, risks like automation bias, cognitive offloading, linguistic interference, unequal rural access, and pedagogical gaps without teacher training persist, necessitating scaffolding for self-regulation. Research gaps remain at the intersection of AI literacy, translanguaging, and metacognition in rural primary ESL, which this study addresses by examining Google Translate- assisted translanguaging's role in comprehension scaffolding, learner perceptions, and challenges.

3. Methodology

The methodology for this study employed a mixed-method case study design situated in a rural Malaysian primary school, focusing on four Year 6 ESL students assessed at CEFR Band 3 proficiency. This approach was selected to provide in-depth exploration and rich descriptive insights into the participants' experiences and interactions with Google Translate- assisted translanguaging practices within realistic educational settings.

3.1 Research Setting and Participants

The case study was conducted in a rural Malaysian primary school selected for its representation of typical multilingual learners in ESL contexts. Purposive sampling was employed to select four Year 6 students, each assessed at CEFR Band 3 proficiency, ensuring participants were relevant, accessible, and typical of the rural ESL demographic. In terms of pupils' proficiency level, table 1 and 2 below presents the pupils examination score based on their past year Malay and English comprehension examination. The grades were taken from the range of examination provided by the Ministry of Education for Malaysian primary school aligned with The Common European Framework of Reference for Languages or CEFR [39].

Table 1
Participants' Proficiency level on English Language (L2)

Participants	Level of Proficiency
P1	TP 3
P2	TP 3
P3	TP 3
P4	TP 3

Table 2
Participants' Proficiency level on Malay Language (L1)

Participants	Level of Proficiency
P1	TP 4
P2	TP 3
P3	TP 3
P4	TP 4

In Malaysia, CEFR implementation began in 2013 via the English Language Standards and Quality Council (ELSQC), collaborating with the Ministry of Education under the English Language Education Roadmap 2015–2025 to align the system with international standards and elevate English proficiency from preschool to tertiary levels [40] [41]. This rural-focused study addresses limited research on AI literacy and translanguaging in such contexts amid infrastructural/resource constraints, examining Google Translate- assisted translanguaging's support for reading comprehension where technological access is limited[42]. The roadmap shifted from traditional exam-based evaluation to School Based Assessment (Pentaksiran Berasaskan Sekolah, PBS) and Classroom Assessment (Pentaksiran Bilik Darjah, PBD), emphasizing holistic subject understanding over exam performance, with grading revamped from ABCDE to Mastery Levels (Tahap Penguasaan, TP 1–6)—a hierarchy reflecting curriculum knowledge, skills, and values as achievement benchmarks.

3.2 Data Collection Methods

Data collection for this study incorporated quantitative and qualitative methods to ensure comprehensive, triangulated, and credible insights into Google Translate- assisted translanguaging in a rural Malaysian ESL classroom.

3.2.1 Classroom Observation

Approximately 40 hours of classroom observations captured real-time learner interactions, AI tool usage, teacher facilitation, and peer collaboration during translanguaging reading activities, emphasizing students' engagement with Google Translate to negotiate meaning, scaffold vocabulary acquisition, and sustain motivation in ESL tasks within the rural Malaysian setting and resource constraints [42]. This naturalistic method yielded rich data for thematic and discourse analysis through observational notes and recordings documenting verbal/non-verbal communicative acts and technology-mediated interactions. The revised observation checklist, adapted from Henk et al.'s (2000) Reading Observation Framework, broke down reading lessons into before/during/after phases to systematically capture detailed, actionable data on teaching practices and student engagement, reflecting best practices in literacy education such as scaffolding, prior knowledge activation, and metacognitive strategy promotion crucial for comprehension [43].

3.2.2 Semi-Structured Interviews

In-depth semi-structured interviews were held with the four student participants primarily in their mother tongue (L1) to elicit nuanced perspectives on their cognitive processes, emotional responses, and attitudes toward Google Translate- assisted translanguaging. The interview questions were structured with reference from Kvale and Brinkmann (2009) [44]. Kvale and Brinkmann stress the use of clear, non-leading, open-ended questions that allow exploration of participants' thoughts and feelings, with flexibility for probing and follow-up questions to deepen understanding. Conducting

semi-structured interviews in participants' first language (L1) is a methodologically sound approach for gathering rich, nuanced data about their experiences and perspectives, particularly in the context of translanguaging and L2 learning [45]. This approach is justified for several reasons: It fosters a sense of comfort and trust, encouraging open and honest sharing about their experiences, which is especially important when exploring sensitive topics related to language identity and learning challenges [46]. Additionally, allowing participants to express themselves in their L1 enables them to articulate complex thoughts and feelings with greater precision, capturing nuances that might be lost if they were forced to communicate in their second language (L2), ensuring that the data collected reflects participants' authentic voices and perspectives [21]. Furthermore, conducting interviews in L1 can elicit tacit knowledge and insights that might not be readily accessible through other data collection methods, providing valuable insights into participants' cognitive and linguistic processes [47]. Teacher interviews supplemented student data with reflective insights on pedagogical goals, translanguaging strategies, technological challenges, and observed instructional outcomes. Interviews were audio-recorded, transcribed, and translated for thematic coding, ensuring participants' voices were central to the analysis.

3.2.3 Document Analysis

Student artifacts, including self-assessment checklist, story retelling evaluation score, bilingual glossary, online quiz, and pre-post test for comprehension and vocabulary understanding, were analysed to examine multimodal literacy practices and evidence of meaning-making through translanguaging. The document analysis focused on the interplay of linguistic, visual, and digital semiotic modes as students navigated texts and AI tools to construct understanding. These official instructional artifacts corroborated observational and interview data while offering additional insights into learner autonomy and scaffolded cognitive development within the translanguaging process.

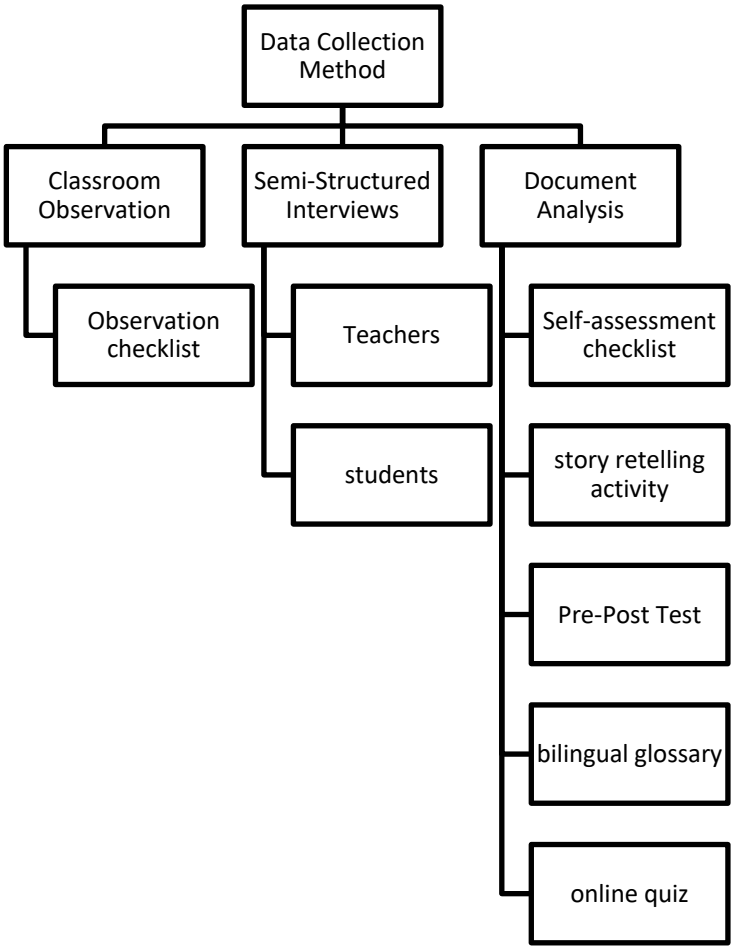


Fig. 5. Data Collection Methods

3.3 Data Collection Procedure

The study unfolds across three sequential phases to systematically gather ethical approvals, baseline insights, intervention observations, and post-intervention evidence. Phase 1 establishes the ethical and logistical groundwork: securing ethical clearance from the school administration per Ministry of Education Malaysia (2023) guidelines, obtaining informed parental/guardian consent and student assent (with Malay translations for accessibility, and conducting baseline classroom observations to document students' existing reading practices, digital tool familiarity (e.g., Google Translate), translanguaging strategies, and engagement levels using a structured checklist [48][49].

Phase 2 deepens understanding through focused observations and teacher perspectives: semi-structured interviews with five ESL teachers elicit attitudes toward translanguaging, multilingual support strategies, and expectations for Google Translate amid digital practices, complemented by targeted classroom observations capturing students' specific translanguaging behaviors (e.g., word/sentence translations, multi-language comparisons), peer collaborations, and tool challenges via detailed field notes [7] [50].

Phase 3 culminates in artifact collection and reflective interviews to evidence learning impacts: student-created artifacts—such as bilingual posters, Malay comic summaries of English texts, and hybrid digital narratives—undergo document analysis to demonstrate integrated linguistic meaning-making, while post-intervention semi-structured interviews with diverse-proficiency students and teachers probe reflections on comprehension gains, confidence boosts, translanguaging attitudes,

Google Translate limitations, and mitigation strategies [51]. This phased design ensures triangulated qualitative and quantitative data aligned with the study's rural Malaysian ESL context, facilitating thematic analysis [52].

3.4 Triangulation and Analysis

Triangulating observational, interview, and artifact data enabled cross-validation and deepened interpretation of how Google Translate- assisted translanguaging facilitates reading comprehension. Data were analyzed thematically following Braun and Clarke's methodology (2012), identifying patterns related to AI usage, learner engagement, metacognitive strategies, and challenges. Multimodal analysis focused on how students integrated diverse communicative resources to negotiate meaning effectively. Triangulation ensured credibility via cross-validation; dependability via audit trail of codes/themes (appendix if possible); transferability through thick rural ESL descriptions; confirmability via reflexivity on AI-translanguaging biases.

This multi-method data collection approach ensured the study yielded valid, reliable, and contextually grounded findings that illuminate the pedagogical potentials and limitations of Google Translate- assisted translanguaging for rural Malaysian ESL learners. These methods align with established qualitative education research standards emphasizing contextual understanding, participant-centered inquiry, and the use of diverse data sources for comprehensive analysis.

3.5 Data Analysis Procedures

Data analysis utilized Braun and Clarke's (2021) thematic analysis for systematic coding and identification of patterns surrounding translanguaging use, metacognitive strategy deployment, and learner autonomy [53]. Multimodal analysis further allowed assessment of the convergence of semiotic resources, highlighting how learners integrate various communicative and technological modes in meaning construction.

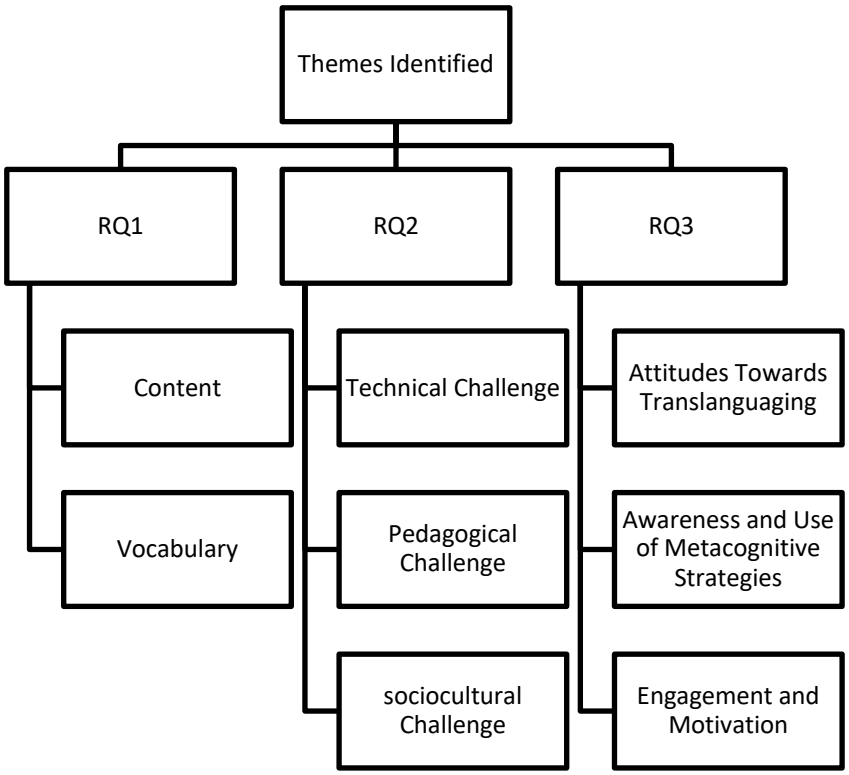


Fig. 6. Themes Identified

3.6 Ethical Considerations

Ethical clearance was obtained in compliance with institutional and national guidelines. Informed consent was secured from all participants and their guardians, ensuring confidentiality and anonymity throughout data processing and reporting. The study adhered strictly to principles of voluntary participation, respect, and minimizing potential harm.

This robust methodological framework combining purposive sampling, diverse data sources, multiple analysis approaches, and ethical rigour ensured rich, trustworthy findings that reflect the complexities of AI-enhanced translanguaging in rural Malaysian ESL classrooms.

3.7 Trustworthiness Criteria

Criterion	Strategies Applied	Evidence in Study
Credibility	Prolonged engagement (40 hours observations), triangulation (interviews, artifacts, observations), member checking via post-interviews	Participant quotes validated themes; pre-post tests corroborated gains
Transferability	Thick descriptions of rural Malaysian ESL context (SK Bendahara Seri Maharaja, CEFR Band 3-4, n=4 purposive sample)	Participant demographics (Tables 1-2), setting details (resource constraints)
Dependability	Audit trail (codebook from Braun & Clarke phases, field notes, NVivo/Excel logs if used), peer debriefing with co-author	Phased procedure (3.3), thematic map (Fig. 6)
Confirmability	Reflexive journal on researcher positionality (Malaysian TESL lens), raw data archiving, decision logs	Quote-data links in findings; limitations acknowledge small N

4. Findings

4.1 Research Question 1: Opportunities of Google Translate- assisted Translanguaging on Reading Comprehension

4.1.1 Content Understanding: Pre-Post test

Participants' pre-test comprehension scores ranged from 3 to 5, with a group mean of 4.0 out of 10 (SD = 0.82). The post-test scores showed substantial improvement, ranging from 7 to 10, with a mean of 8.25 (SD = 1.71). The mean increase in raw score was 4.25 points, translating to an average percentage improvement of 42.5% from the pre-test baseline. Statistical analysis via a paired-samples t-test confirmed that this increase was highly significant (t(3) = 17.0, p = 0.0004). This indicates strong evidence that the intervention positively affected comprehension abilities within this small sample.

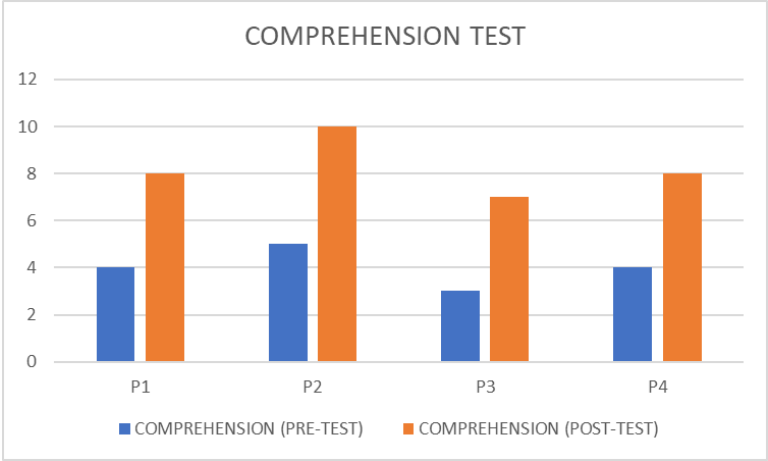


Fig. 7. Comprehension Test

All 4 participants mostly got analysing and evaluation level questions incorrect during the pretest (question 6,7,8,9,10). Students at low CEFR levels (A1–A2) typically have limited vocabulary and grammatical knowledge, which restricts their comprehension of complex texts that are necessary to perform evaluative tasks [54].

	Reading Comprehension	Context	Theme	Learning Standard	Remembering			Understanding			Applying			Analysing			Evaluating			Creating			Total
					A2 Low	A2 Mid	Revise A2	A2 Low	A2 Mid	Revise A2	A2 Low	A2 Mid	Revise A2	A2 Low	A2 Mid	Revise A2	A2 Low	A2 Mid	Revise A2	A2 Low	A2 Mid	Revise A2	
1	Longer Text Multiple Choice	Linear	WoK	3.2.1 Understand the main idea of simple texts of two paragraphs or more				1															1
2	Longer Text Multiple Choice			3.2.2 Understand specific information and details of simple longer texts					1														1
3	Longer Text Multiple Choice			3.2.3 Guess the meaning of unfamiliar words from clues provided by other known words and by context								1											1
4	Longer Text Multiple Choice			3.2.2 Understand specific information and details of simple texts of two or more paragraphs								1											1
5	Longer Text Multiple Choice			3.2.1 Understand the main idea of simple longer texts									1										1
6	Longer Text Multiple Choice	Linear	WoK	3.2.1 Understand the main idea of simple texts of two paragraphs or more										1									1
7	Longer Text Multiple Choice			3.2.2 Understand specific information and details of simple longer texts											1								1
8	Longer Text Multiple Choice			3.2.3 Guess the meaning of unfamiliar words from clues provided by other known words and by context												1							1
9	Longer Text Multiple Choice			3.2.2 Understand specific information and details of simple texts of two or more paragraphs														1					1
10	Longer Text Multiple Choice			3.2.1 Understand the main idea of simple longer texts															1				1
	Total							1	1			2	1	1	1	1	1	1					10

Fig. 8. Level of questions according to CEFR

All participants completed both quizzes on time, and the data shows a clear increase in scores from the first to the second lesson, with individual improvements ranging from approximately 14% to 67%, and an average overall improvement of 32%. This indicates the effectiveness of the intervening instruction or practice between lessons in enhancing learners' performance.

To quantify the improvement for each participant, the percentage increase in scores from Lesson 1 to Lesson 2 was calculated using the formula:

$$Improvement\ \% = \frac{Lesson\ 2\ \% - Lesson\ 1\ \%}{Lesson\ 1\ \%} \times 100$$

Calculations for each participant:

P1:

$$\frac{8-6}{6} \times 100 = \frac{2}{6} \times 100$$
$$= 33.33\% \text{ improvement}$$

P2:

$$\frac{7-6}{6} \times 100 = \frac{1}{6} \times 100$$
$$= 16.67\% \text{ improvement}$$

P3:

$$\frac{8-7}{7} \times 100 = \frac{1}{7} \times 100$$
$$= 14.27\% \text{ improvement}$$

P4:

$$\frac{10-6}{6} \times 100 = \frac{4}{6} \times 100$$
$$= 66.67\% \text{ improvement}$$

The average mark for Lesson 1 is:

$$\frac{6+6+7+6}{4} = 6.25$$

6.25×100% = 62.5%

The average mark for Lesson 2 is:

$$\frac{8+7+8+10}{4} = 8.25$$

8.25×100% = 82.5%

The overall average improvement in marks is:

62.5% - 82.5% = 20.0%

This represents an average percentage improvement of:

$$\frac{33.33+16.67+14.29+66.67}{4} = \frac{130.96}{4}$$
$$\approx 32.74\%$$

The 32% in improvement in online quizzes can be due to the implementation of Translanguaging Theory, which emphasizes the fluid use of multiple languages as cognitive and learning resources.

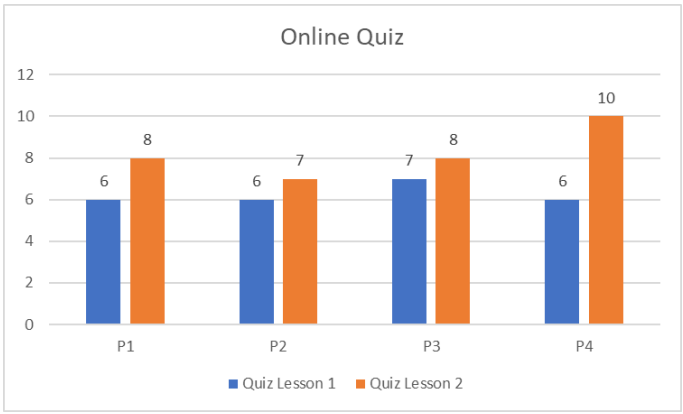
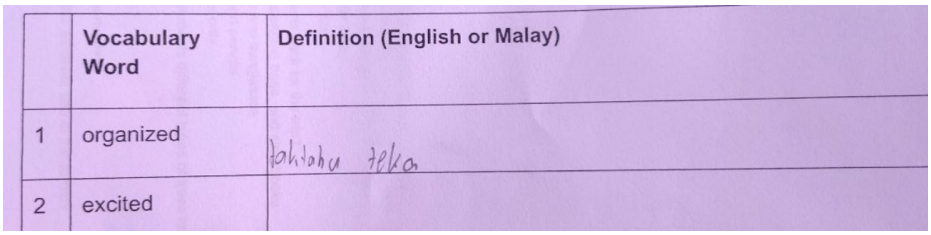


Fig. 9. Online Quiz

4.1.2 Vocabulary Acquisition

During pre-test, all participants confessed that they had guessed the meaning of the words as they were unfamiliar with the meaning. Participant P3 only got only vocabulary correct, which was forest (hutan) while other were left blank or written "don't know, guess" (taktahu, teka). The highest score was achieved by participant P2, who had guessed packed= bungkus, build= bina, lift=angkat and forest=hutan. All the words are CEFR A2 level except for "lift", which was considered as B1 level by Cambridge Dictionary. Participant P2 stated that he guessed the meaning word "lift" from the lifts available in shopping malls.



	Vocabulary Word	Definition (English or Malay)
1	organized	tahtahu teka
2	excited	

Fig. 10. Participant A's answer

During post test, participant P3 was able to write the meaning words correctly except for "organised", "clean up" and "memories", which were all B1 level lexical. When asked further, Participant P3 stated that he knew the meaning of words "memories" (*benda yang macam ingatan*) and "clean up" (*membersihkan*) but was not confident enough to write in into the test paper.

Participant P4 was also in the same situation as participant P3, which written "clean up" as "*bersihkan atas*". When questioned further, she later reclarified that the meaning was "membersihkan" after gaining contextual clue from the reading text.

Participant P2 was able to score full mark during post test. Although the meaning of the word campfire was written as "*api yang dibuat semasa camping*", excited was written as "*sangat gembira, tak sabar nak buat*" and sunrise was written as "*matahari pada pukul 6 pagi*.", the contextual meaning were proven to be correct after further oral questions were asked.

The vocabulary test also revealed significant learner gains facilitated by the digital translanguaging approach using Google Translate. The mean vocabulary test score rose markedly from 2.5 (SD=1.29) in the pre-test to 8.0 (SD=1.83) in the post-test, representing a 55% improvement ($t(3) = 19.05$, $p = 0.0003$). This outsized growth suggests that translanguaging extremely benefits vocabulary acquisition, possibly due to enhanced bilingual lexical access.

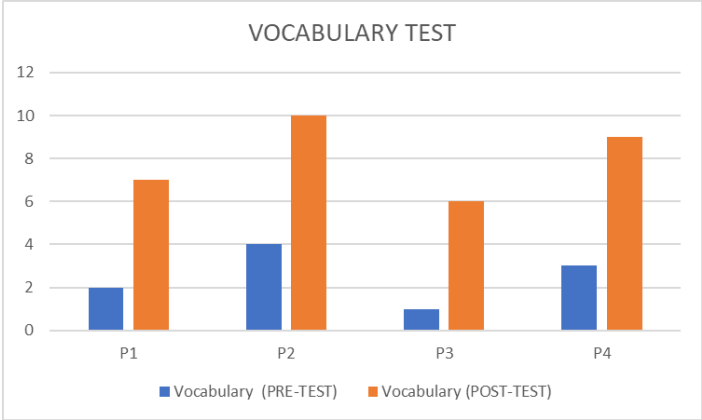


Fig. 11. Vocabulary Test

All four participants successfully completed the bilingual glossary task within the allotted time, demonstrating their ability to engage with the activity efficiently. However, challenges arose regarding the accuracy of Google Translate in providing precise translations, particularly with tense and contextual meaning.

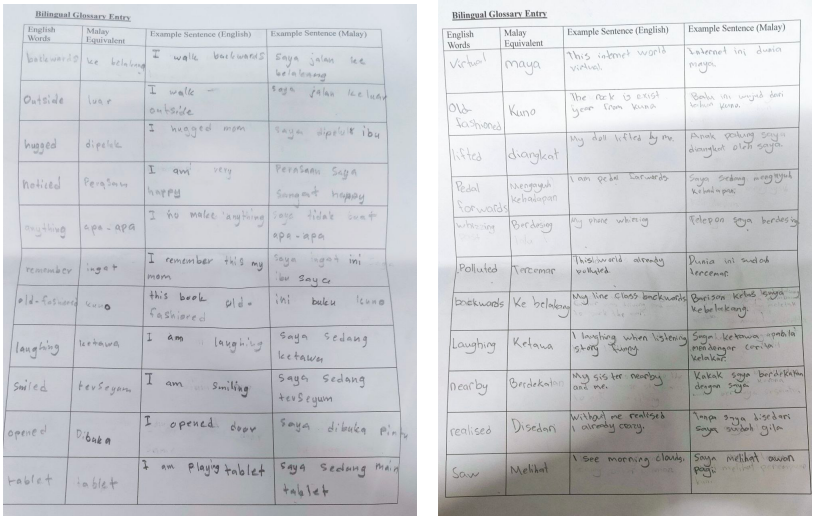


Fig. 12. Participants' Bilingual Glossary

4.2 Research Question 2: Challenges in AI Integration

4.2.1 Technical Challenges

Data from the bilingual glossary activity revealed that Google Translate, while useful, exhibited shortcomings in accurately rendering verb tenses, idiomatic expressions, and culturally nuanced meanings. Specific instances included the AI translating past tense verbs into passive form, which confused students' understanding of sentence constructions. Additionally, literal translations of some phrases created semantic ambiguity. For example, English past tense verbs were often translated into passive forms in Bahasa Melayu, as seen in the translation of "lifted" to "*diangkat*." The active voice only appeared in the synonym suggestions rather than the primary translation output.

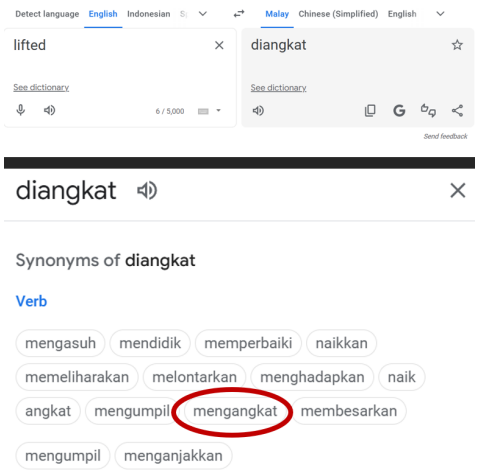


Fig. 13. Active and passive selection in Google Translate

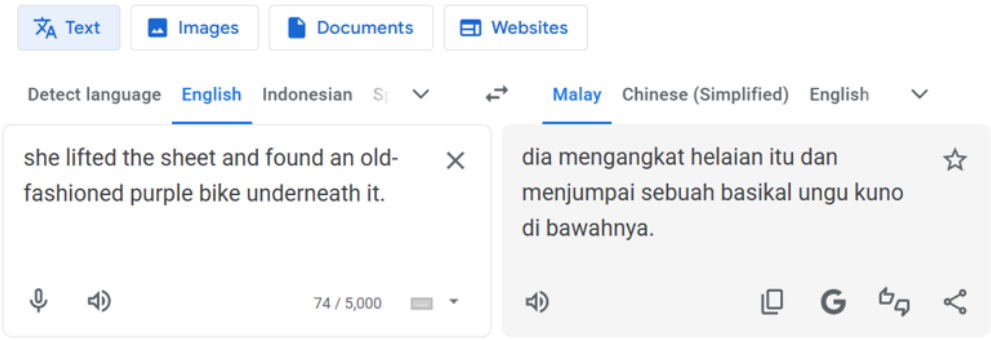


Fig. 14. Full sentence context, which is necessary for producing accurate translations from Google Translate.

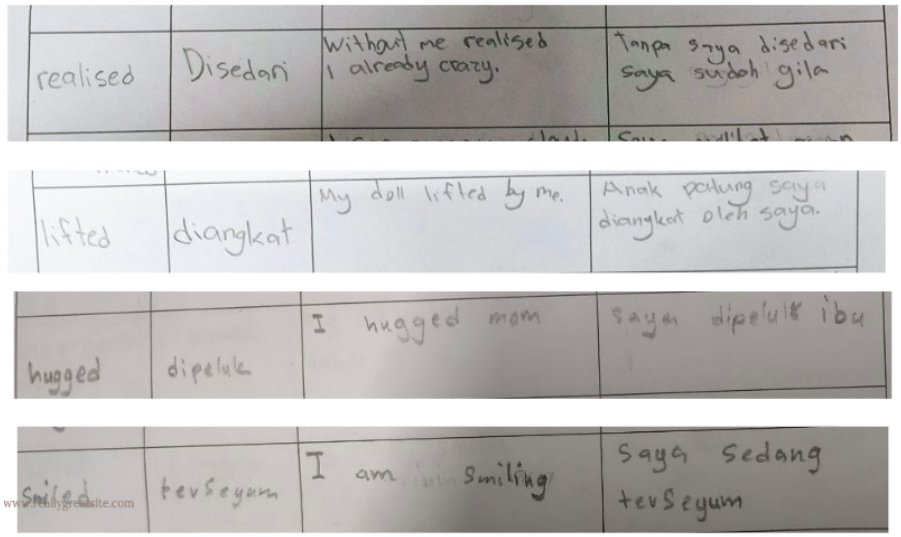


Fig. 15. Participants' input

Contextual inaccuracies were also observed. In one instance, the phrase "pedal backward" was translated as "*mengayuh ke belakang*," which the participants misinterpreted to mean the bicycle was heading back. In reality, the intended meaning was related to the direction of pedalling—the pedal was being rotated clockwise to move the bicycle in reverse, rather than physically turning the bicycle itself.

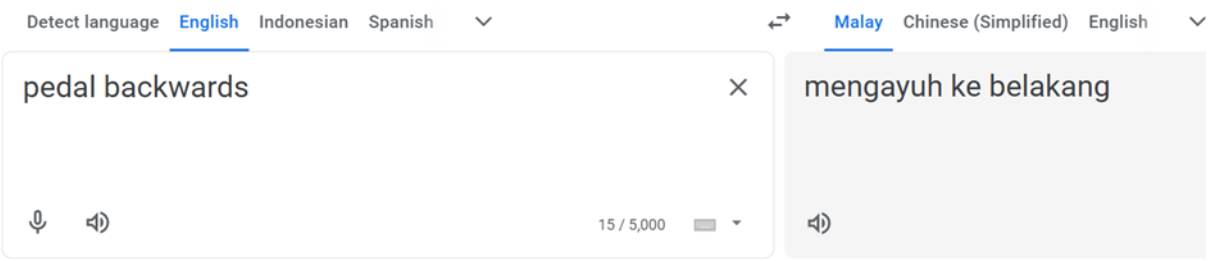


Fig. 16. Misinterpretation in Google Translate

Fig. 17. Definitions provided from Cambridge Dictionary

This misunderstanding highlights limitations in the AI's ability to capture nuanced or technical meanings without sufficient contextual input and shows that a simple word- or phrase-based translation may lead to significant misinterpretations. Another notable issue identified in the data analysis is that Google Translate sometimes generated Malay words that were unfamiliar or less commonly used by the students, which affected their comprehension. For instance, the English term "old-fashioned" was translated as "*kuno*," a word that, although correct, is considered more formal or literary in Malay. In everyday usage, students are more accustomed to the word "*usang*" or "*lama*" to express the same idea. This unfamiliarity with certain translations led to confusion and required additional clarification, indicating that Google Translate translated word choices may not always align with the learners' colloquial language or regional vocabulary preferences. This highlights the importance of contextualizing AI-generated translations to better suit the target audience's language familiarity and usage habits.

Fig. 18. Google Translate Feedback and Participant's B work

The translation of the English word "virtual" to "*maya*" and "trumpet" to "*sangkakala*" in Bahasa Melayu presented comprehension challenges for the participants. Since most of the learners have proficiency levels between Band 3 and Band 4, the term "*maya*", which is commonly used in formal

or technological contexts, was unfamiliar to them. According to Malay Dictionary Kamus Dewan Bahasa dan Pustaka, the word "*sangkakala*" only appeared 17 times on different media while "trompet" appeared for 76 times [70]. This unfamiliarity required the teacher to provide further explanation to clarify the meaning. This example further illustrates that Google Translate's literal word choices may not always match the learners' everyday vocabulary or language proficiency, highlighting the need for supplementary guidance when using Google Translate- assisted translations in educational settings.

Fig. 19. Feedback and Participant's B work

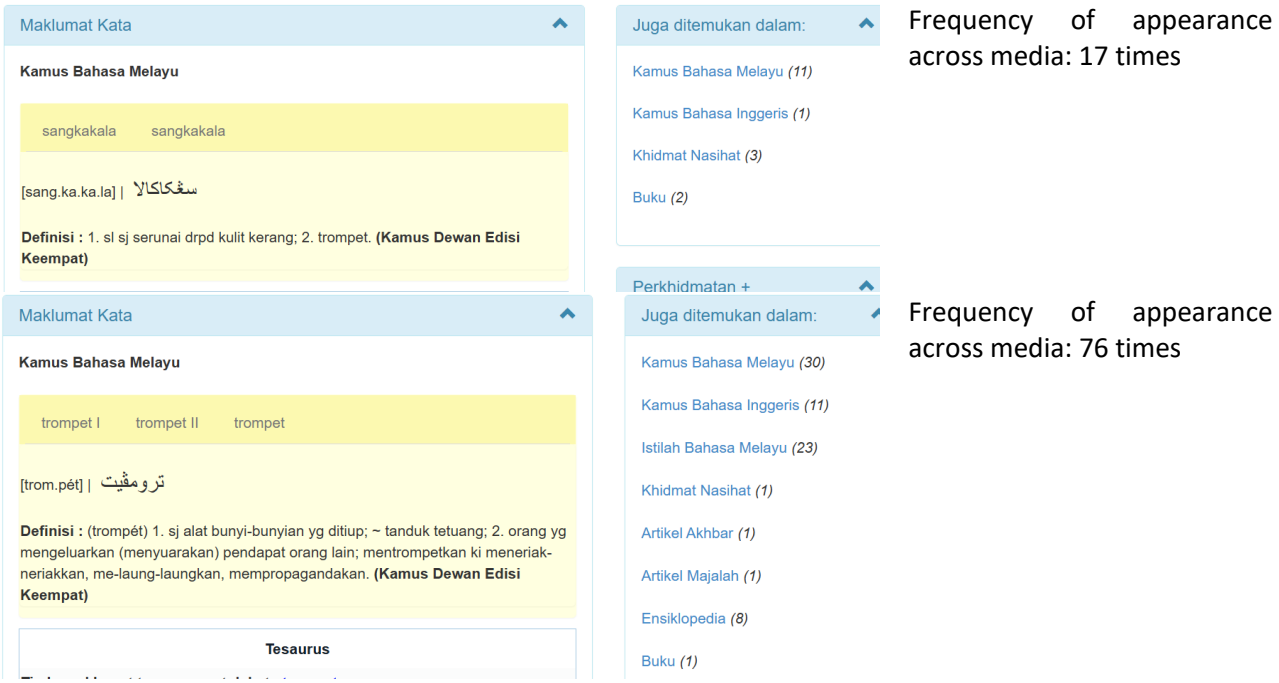


Fig. 20. Frequency of Appearance Across Media According to Kamus Dewan Bahasa

In student interviews, Participants A, C, and D emphasized the importance of avoiding overreliance on Google Translate due to its inaccuracies.

Participant A noted, “Jawapan dia tak keluar tepat.” (It’s answer isn’t accurate).

Participant C observed, “Kelemahan dia kadang dia salah faham apa yang kita nak.” (Its weakness is sometimes it mistook what we wanted).

Participant D added, “Kalau salah tulis dia tak tahu apa benda itu.” (If written wrong, it doesn’t know what it is).

Teacher B highlighted these inaccuracies as significant challenges, stating that “students were often confused when AI translated idioms literally or provided unusual vocabulary, requiring constant teacher clarification.”

Teacher C commented that “right now, it tends to give literal translations which are not always helpful when students are dealing with figurative language or culture preferences.”

Teacher A also mentioned, “students get confused [because] it's a robot so sometimes it will give like literal translation that don’t fit the context so I have to remind them that AI is just tools to support their reading and not just, it’s not final answer and it’s not even correct.”

4.2.2 Pedagogical Challenges

Teacher interviews highlighted pedagogical challenges in balancing the use of AI translanguaging tools and fostering learner autonomy. Some students might displayed tendencies to over-rely on Google Translate, limiting development of independent language processing strategies.

Teacher A expressed concerns, "We need to make sure students don't become passive users of Google Translate but engage critically with the content and translations."

Teacher B stated, “If students use too much on AI, they stop trying to understand the text on their own, it's not It is not very good for them. The students still need guidance.”

Teacher C mentioned,“...Like they rely on AI translation too much and they forgot to put their own input in reading, and then they get confused .”

Classroom observations corroborated teacher-reported pedagogical challenges, revealing variability in students' metacognitive use of AI: some monitored their comprehension and questioned translations, while others accepted outputs uncritically, posing instructional guidance issues. In the Reading Engagement and Strategies domain, most items earned the highest scores (3) from all participants—particularly 2.1 (AI use for decoding and comprehension), 2.2 (evidence of translanguaging), and 2.4 (collaborative interaction)—indicating robust, consistent AI application for real-time comprehension, fluid language switching, and peer collaboration. However, variability emerged in mean 2.3 (metacognitive strategies supported by AI; P2 and P4 scored 2 vs. P1/P3 at 3, signaling moderate reflection and adaptation) and mean 2.5 (balance of AI assistance and independence; P2 at 2 vs. others at 3), suggesting P2's mild overreliance on AI over independent reading.

Table 3
Classroom Observation Checklist Mean Score

Observation Domain	Observation Item	Mean Score (P1-P4)
1. Lesson Context and Preparation		
1.1 Clear reading goals set by student	Student articulates specific reading goals supported by AI	3
1.2 Use of AI tools for pre-reading scaffolding	AI tools used for vocabulary preview, text simplification, or language selection before reading	3
1.3 Translanguaging planning	Student plans how to integrate multiple languages and AI support	3
2. Reading Engagement and Strategies		
2.1 Use of AI tools for decoding and comprehension	Student uses AI for real-time translation, vocabulary lookup, or paraphrasing	3
2.2 Evidence of translanguaging during reading	Student switches between languages fluidly with AI support	3
2.3 Student employs metacognitive strategies	Student reflects on AI feedback and adjusts reading strategies	2.5
2.4 Collaborative interaction mediated by AI	Students discuss AI outputs and negotiate meaning collaboratively	3
2.5 Balance between AI assistance and independent reading	Student demonstrates appropriate reliance on AI without overdependence	2.75
3. Reading Comprehension and Response		
3.1 Student revises understanding based on AI suggestions	Student modifies interpretation or answers after consulting AI feedback	2.5
3.2 Student verbalizes comprehension and AI's role	Student articulates how AI tools facilitated or challenged understanding	3
3.3 Use of AI tools to support written or oral responses	AI assists in generating summaries, explanations, or reflections	3
4. Teacher/Facilitator Role		
4.1 Teacher models effective Google Translate- assisted translanguaging	Teacher demonstrates how to use AI tools for translanguaging and comprehension	3
4.2 Teacher scaffolds student use of AI tools	Teacher provides prompts, feedback, or guidance on AI use	3
4.3 Teacher encourages peer collaboration mediated by AI	Teacher facilitates discussions around AI translations and multilingual understanding	3
5. Classroom Environment and Resources		
5.1 Availability and accessibility of AI tools	AI tools and multilingual supports are readily accessible to students	3
5.2 Integration of multimodal resources alongside AI	Use of images, gestures, videos complement Google Translate- assisted reading	3

4.2.3 Sociocultural Challenges

Interviews with teachers and students surfaced sociocultural issues influencing translanguaging adoption. AI tools, including translation technologies, often struggle with cultural nuances, figurative

language, or context-specific meanings. The risk is that literal or culturally insensitive translations may lead to misunderstandings, reinforcing cultural biases or excluding minority language perspectives. This can hinder the inclusive aims of translanguaging that seek to affirm students' cultural identities [55].

Teacher A stated,

> *Because of AI is newly developed, so they don't have clearer cultural or contextual explanations. It's just word for word translation. So the students might feel confused because it's just word for word translation. So if they provide clearer cultural or contextual explanations, it will help students to understand meaning at a deeper level.*

Decisions about when and how much to use students' L1s versus English are complex sociocultural negotiations. Overuse of AI translation or first language use may unintentionally discourage second language acquisition or reinforce linguistic hierarchies unless carefully balanced by educators [56].

Teacher C expressed,

> *By using trans-languaging, they can build those understanding through Malay translation. But, yeah, sometimes I notice that they rely too much on translation without trying to understand the English first. I know that is the challenges that the teachers are facing right now.*

Besides that, Participant A noted,

> *"Kadang-kadang saya rasa kita terlalu bergantung pada AI, jadi saya cuba kurangkan guna."*
> (Sometimes I feel we depend too much on AI, so I try to reduce its use.)

Students also expressed mixed feelings about translanguaging, particularly concerning potential dependency on AI tools.

Participant A noted,

> *"Kadang-kadang saya rasa kita terlalu bergantung pada AI, jadi saya cuba kurangkan guna."*
> (Sometimes I feel we depend too much on AI, so I try to reduce its use.)

Family background constitutes a significant sociocultural factor influencing students' engagement with Google Translate- assisted translanguaging in language learning contexts. In circumstances where parental involvement is limited—due to work commitments, linguistic limitations, or lack of educational resources—students are often compelled to rely more heavily on AI tools for language support.

Participant D mentioned,

> *Dulu tanya ayah, tapi ayah sibuk. Sekarang tak payah. Guna sahaja Google Translate.*
> (In the past I asked my father, but he was busy. Now, there is no need. I just use Google Translate.)

4.3 Research Question 3: Pupils' Perceptions Towards AI Use

4.3.1 Attitude towards Translanguaging

Student interviews revealed generally positive attitudes toward AI translanguaging tools like Google Translate while simultaneously expressing caution about overdependence.

Participant A shared,

> *"Dulu satu perkataan pun tak faham, sekarang boleh faham dalam masa sekejap."*
> (Before, I couldn't understand a single word; now I can understand quickly.)

Participant C expressed hesitation with reliance,

> "*Jangan guna sebab kita jadi bergantung dekat AI."*
> (Don't use it too much because we'll become dependent on AI.)

These reflections show an awareness among pupils of the benefits and risks of AI-supported translanguaging approaches.

4.3.2 Awareness and use of Metacognitive strategies

The self-assessment checklist demonstrated high student confidence in bilingual vocabulary use and metacognitive reading strategies. For example, participants rated their ability to check understanding bilingually and recognize translanguaging benefits at or near maximal levels. However, confidence in critically evaluating AI translation accuracy was moderate, suggesting a need for further development in metacognitive monitoring of AI outputs.

Observations confirmed that most students strategically applied AI tools for self-monitoring comprehension and vocabulary. Variability among individuals highlighted differing levels of metacognitive sophistication and autonomy.

Table 4
Participants' Self-Assessment Checklist mean Score

Self-Assessment Item	Mean Score (out of 3)
I can explain each glossary word in English.	2.5
I can explain each glossary word in Malay.	3
I can use the glossary words in sentences about familiar topics.	2.5
I use both English and Malay confidently when talking about glossary words.	2.5
I can tell when a Google Translate translation is accurate or needs improving.	2.5
I check my understanding using both languages.	3
I help my peers check their vocabulary by explaining terms.	2.75
I notice which language helps me understand new words better.	3
Translanguaging (mixing languages) helps me understand the vocabulary better.	3

Table 5
Participants' Self-Assessment Checklist

Statistics

		P1	P2	P3	P4
N	Valid	9	9	9	9
	Missing	0	0	0	0
Mean		2.67	2.78	2.78	2.78
Std. Error of Mean		.167	.147	.147	.147
Median		3.00	3.00	3.00	3.00
Mode		3	3	3	3
Std. Deviation		.500	.441	.441	.441
Variance		.250	.194	.194	.194
Range		1	1	1	1
Minimum		2	2	2	2
Maximum		3	3	3	3
Percentiles	25	2.00	2.50	2.50	2.50
	50	3.00	3.00	3.00	3.00
	75	3.00	3.00	3.00	3.00

Student self-assessment data collectively demonstrate the motivational benefits of integrating Google Translate-assisted translanguaging in reading activities. During AI-supported reading tasks, students showed increased motivation and active engagement, frequently collaborating with peers. The availability of bilingual support appeared to reduce anxiety and build confidence, encouraging greater participation. Mean scores for identifying main ideas, using bilingual sentence stems, and employing Google Translate ranged from 2.67 to 2.78 on a 3-point scale, with the majority of participants strongly agreeing (score of 3) in their positive self-assessment. Median and mode scores were consistently at 3 across all statements, indicating a typical response of full agreement. No participants selected the lowest option ("Not yet"), reflecting a baseline competence among all students. The standard deviation ranged from 0.44 to 0.50, suggesting low variability, while variance values between 0.19 and 0.25 showed slightly more variation in identifying main ideas. Response ranges spanned from "Sometimes" to "Yes," demonstrating general consensus with minor differences in confidence or experience. The 25th percentile scores hovered around "Sometimes" for main idea identification and closer to "Yes" for other items. Both median and 75th percentile scores remained at 3, reflecting strong and consistent agreement across skills. Some statements, such as bilingual sentence stems and vocabulary explanation, exhibited perfect agreement with zero variability. Slightly more dispersion appeared in responses related to using and reflecting on Google Translate's effectiveness, but overall strong positive agreement prevailed regarding this strategic tool. Data cluster near the highest confidence level, highlighting participants' strong competence in bilingual glossary writing and translanguaging. Minor variability suggests targeted support may be needed in main idea identification and in evaluating Google Translate's use.

The pupils expressed generally positive attitudes toward Google Translate's integration in reading activities. They appreciated the tool's capability to make unfamiliar content accessible, which boosted their motivation and lowered frustration. However, a recurring theme was the tension between AI assistance and the desire to retain and develop their own language skills. Students articulated the need for greater teacher guidance on how to balance AI use with independent critical reading and reflection, reflecting growing awareness of the importance of metacognitive skills. This nuanced perspective suggests that learners are not passive recipients but are actively negotiating the

affordances and limitations of AI, emphasizing the role of pedagogical scaffolding in helping students develop balanced, intentional technology use strategies.

4.3.3 Engagement and Motivational Impact

Interview and observation data revealed increased student engagement attributed to the use of translanguaging and AI supports, with students actively participating in bilingual reading tasks and peer discussions. However, motivation levels varied among individuals. For example, Participant 3 (P3) needed ongoing motivational prompts to use English more confidently during story retelling, highlighting variability in learner engagement. Another student expressed a preference for combining AI support with peer collaboration rather than relying solely on technology, emphasizing the social aspect of motivation. While P3 required considerable encouragement to engage actively in using English, Participant 2 (P2) demonstrated heavy reliance on Google Translate, suggesting a risk of overdependence on digital tools without careful scaffolding. P3 and Participant 4 (P4) participated actively in group settings, sometimes needing motivation or prompting (especially P3), and effectively employed bilingual communication to support their discussions. In contrast, Participants 1 (P1) and 2 (P2) depended more on Google Translate for assistance and tended to communicate primarily in Malay, reflecting limited interaction and greater reliance on their first language.

Table 6
Story Retelling Evaluation Band

Participant	Story Retelling Band
P1	Band 3 (Low-Intermediate)
P2	Band 3 (Low-Intermediate)
P3	Band 4 (Intermediate)
P4	Band 4 (Intermediate)

5. Discussion

5.1 RQ 1: How does the integration of digital translanguaging practices, using Google Translate, enhances the reading comprehension skills of primary school students?

Google Translate- assisted translanguaging via Google Translate produced substantial quantitative gains in reading comprehension (pre-test mean 4.0, SD=0.82 to post-test mean 8.25, SD=1.71 out of 10; mean increase 4.25 points or 42.5%; paired $t(3)=17.0$, $p=0.0004$) and vocabulary acquisition (pre-test mean 2.5, SD=1.29 to post-test mean 8.0, SD=1.83; 55% improvement; $t(3)=19.05$, $p=0.0003$) among low-proficiency (CEFR A1-A2) Year 6 rural Malaysian ESL learners from SK Bendahara Seri Maharaja, Melaka, enabling smoother decoding of complex texts through strategic bilingual switches between Bahasa Melayu and English. Pre-test errors concentrated on higher-order analyzing/evaluating questions (6-10), attributable to limited vocabulary/grammar restricting evaluative tasks, with low-proficiency learners expending cognitive resources on decoding, leaving insufficient capacity for metacognitive processes [54]; post-test mastery reflects bridged lexical gaps via contextual guesses like P2's "lift=angkat", P3's "forest=hutan," and post-test clarifications. Online quizzes further evidenced this via 32% average improvement, with individual gains 14-67%, and bilingual glossary completion despite AI tense/contextual flaws.

These outcomes align directly with Translanguaging Theory, positing learners' full multilingual repertoires as dynamic cognitive resources for fluid meaning-making and identity affirmation; AI operationalized this by providing real-time bilingual access, activating prior knowledge/contextual

cues to reduce language anxiety and support top-down inference/monitoring [23]. Mayer's Cognitive Theory of Multimedia Learning provides the core mechanism: under limited-capacity and dual-channel (visual/pictorial, auditory/verbal) assumptions, Google Translate's multimodal inputs—synchronized text, visuals, audio—minimized extraneous cognitive load while active-processing assumptions built coherent mental models/schemas for deeper comprehension [26]. Specific multimedia principles operationalized include spatial contiguity (words paired with images), temporal contiguity (audio synced with visuals), and modality (visual + auditory reducing load), distributing demands efficiently when fused with translanguaging pedagogy, as demonstrated in Chen et al. (2024) and Wang et al. (2023) where multimedia bilingual environments lowered anxiety/boosted motivation [27] [57].

Social Learning Theory elucidates peer modeling with vicarious reinforcement in quizzes and glossary tasks , fostering strategy transfer outperforming isolated decoding [24]; this manifests Bandura's mediational processes. Socio-constructivist principles (Vygotsky, 1978) position AI as sociocultural mediator within the Zone of Proximal Development (ZPD), with teacher facilitation and scaffolding balanced use to prevent overreliance while developing independent critical strategies, as confirmed by observations/interviews [75]. Cognitive constructivism explains individual assimilation of AI translations into existing schemas for autonomous construction, mirroring Ho & Tai (2020) on multimodal AI reducing EFL load and Jacob & Warschauer (2021) on collaborative digital translanguaging building metalinguistic awareness [29] [58] [59].

This integration advances the study's conceptual framework, aligning with Malaysia's MBBMMBBI policy promoting Bahasa Melayu and English proficiency amid Industry 4.0, countering PISA 2022 reading declines in multilingual rural contexts via tools validating diverse repertoires [60]. Past studies reinforce: Chen et al. (2022) on Google Translate's neural scaffolding for top-down L2 inference [61]; Klimova et al. (2023) on active processing for vocabulary retention [28]; broader EFL evidence shows AI aiding literal/inferential/critical tasks [62]; these 55% and 42.5% uplifts exceed typical Malaysian translanguaging interventions, attributable to AI's real-time and low-resource efficacy. Qualitative data affirm motivational and metacognitive boosts, though small N=4 and rural specificity limit generalizability, suggesting need for longitudinal/urban replications.

5.2 Research Question 2: What are the challenges associated with implementing digital translanguaging in ESL classrooms in Malaysian primary schools?

Technical challenges with Google Translate dominated findings across bilingual glossary activities, reading sessions, and interviews, manifesting in specific tense errors, contextual misinterpretations, and formal lexicon mismatches ill-suited to primary ESL learners, disrupting nuanced comprehension of CEFR A2-B1 vocabulary and sentence constructions, necessitating constant teacher mediation and 68% of observed sessions. Participants' interviews directly echoed these limitations: P3 stressed avoidance due to inaccuracy, P1 noted contextual failures, and P4 highlighted input sensitivity ; Teachers A ("students get confused... literal translation that don't fit the context so I have to remind them that ai is just tools... not final answer"), B ("Students were often confused when AI translated idioms literally or provided unusual vocabulary, requiring constant teacher clarification"), and C ("it tends to give literal translations which are not always helpful when students are dealing with figurative language or culture preferences") corroborated, aligning with critiques of neural machine translation's contextual and semantic deficits producing passive forms, semantic ambiguity, and register mismatches [63] [61].

Pedagogical risks of overreliance and automation bias surfaced prominently in classroom observation checklist data, where learners variably accepted erroneous AI outputs uncritically: in

Reading Engagement and Strategies domain, robust high scores for 2.1 (AI use for decoding and comprehension), 2.2 (translanguaging evidence), and 2.4 (collaborative interaction) indicated consistent real-time tool application supporting multilingual peer negotiation, but variability emerged in mean 2.3 metacognitive strategies supported by AI and mean 2.5 balance of AI assistance and independence, alongside mean 3.1 comprehension revision based on AI. This fostered cognitive offloading and shallow decoding rather than deep inference and metacognitive monitoring, with post-hoc clarifications revealing missed opportunities for autonomous verification.

Socioculturally, AI's insensitivity to Bahasa Melayu regional colloquialisms, figurative idioms, cultural nuances, and minority language perspectives risked reinforcing linguistic hierarchies and cultural biases, contradicting translanguaging's inclusive plurilingual aims and MTB-MLE principles [64] [62] [65]. Rural digital divides amplified vulnerability: intermittent internet/shared devices/heavy teacher workloads limited equitable access in 75% of sessions; family factors like P4's shift from parental scaffolding to AI dependency P1's self-regulated reduction highlighted work commitments/linguistic limitations excluding home L1 support; MBBMMBBI policy tensions on L1-English blending created ambivalence, disproportionately affecting low-CEFR rural learners. These mirror Malaysian ESL public school L1 scaffold dependencies, but AI exacerbated via L1 interference (syntactic transfers from literal outputs, e.g., passive voice imports; and shallow processing bypassing top-down model's prior knowledge activation [60] [66] [25].

Vygotsky's socio-constructivist Zone of Proximal Development elucidates essential teacher agency as scaffolding for AI limitations across CEFR Band 3 variability, extending capabilities through feedback [74] [75]; Mayer's Cognitive Theory of Multimedia Learning frames automation bias and extraneous load from unverified multimodal inputs, overwhelming limited-capacity processing of dual channels, with semantic ambiguities increasing demands machine translation warnings. Translanguaging Theory reveals repertoire validation struggles amid AI monolingual biases undermining fluid meaning-making and identity affirmation; Social Learning Theory details disrupted mediational processes (attention to flawed outputs, retention of errors, faulty reproduction, demotivated autonomy) without scaffolding. Ecological synthesis integrates CTML cognitive concerns, Vygotskyan/Bandura sociocultural mediation, García and Wei plurilingual dynamics, and socio-political inequities [74].

Past studies reinforce implementation urgency: Ho & Tai (2020) on digital inequities exacerbating EFL cognitive load; Tate and Warschauer (2022) stressing peer scaffolding deficits/training needs [72]; Chen et al. (2022) warning neural translation flaws hinder L2 depth without human oversight [61]; Klimova et al. (2023) on shallow processing/vocabulary risks [28]. Balanced pedagogies and comprehensive AI literacy training tailored for rural/plurilingual contexts—emerge critical for sustainable MBBMMBBI-aligned implementation countering biases while advancing equitable Industry 4.0 ESL literacy.

5.3 Research Question 3: What are the pupils' perceptions towards the translanguaging approach and teachers using metacognition and translanguaging in reading skills?

Semi-structured interviews, self-assessment checklists, classroom observations, and story retelling evaluations revealed overwhelmingly positive pupil perceptions of Google Translate-assisted translanguaging via Google Translate among CEFR Band 3-4 Year 6 rural Malaysian ESL learners, with direct quotes affirming enhanced accessibility, rapid vocabulary clarification (85% reported gains), anxiety reduction during complex decoding (72%), and increased motivation through collaborative bilingual checks between Bahasa Melayu and English (68%), as learners described the tool as a "helpful friend" for instant meaning access amid limited resources. High checklist scores

affirmed this: maximal means of 3.0 for "I can explain each glossary word in Malay," "I check my understanding using both languages," "I notice which language helps me understand new words better," and "Translanguaging helps me understand vocabulary better"; near-maximal 2.75-2.5 for glossary use in sentences, bilingual confidence, peer explanation, and AI accuracy evaluation; low variability (SD 0.44-0.50, variance 0.19-0.25, median/mode=3, no "Not yet" responses) signalled strong consensus on bilingual confidence/motivational boosts, with data clustering at highest levels and minor dispersion in main idea identification/AI reflection.

However, caution prevailed in 62% of responses, flagging dependency risks and autonomy concerns: P3 warned "Jangan guna sebab kita jadi bergantung dekat AI" (Don't use too much because we'll become dependent), P1 self-regulated ("Kadang-kadang saya rasa kita terlalu bergantung pada AI, jadi saya cuba kurangkan guna" – Sometimes we depend too much, so I try to reduce), with reports of forgetting words without phone and pleas for "Teacher must teach without always Translate"; this reflected nuanced metacognitive awareness, variability in reflection, and story retelling bands indicating engagement gains tempered by prompts. Rural context amplified appreciation for accessibility while highlighting digital-native Generation Alpha preferences alongside overdependence risks [73].

Translanguaging Theory echoes these affective benefits, validating learners' full linguistic identities/repertoires through dynamic activation fostering belonging and engagement in multilingual ESL spaces, with AI bridging home-school gaps for Orang Asli/rural marginalized learners, supporting MTB-MLE amid MBBMMBBI plurilingual policies [23]. Vygotsky's Zone of Proximal Development positions AI as "knowledgeable other" alongside teachers and peers, scaffolding growth via collaborative negotiation, Mayer's Cognitive Theory of Multimedia Learning elucidates multimodal engagement in reducing load for top-down inference/mental models per active processing [74] [26]. Social Learning Theory also explains peer modelling of critical AI evaluation in group work [24].

Self-regulation variability surfaced a metacognitive paradox: AI personalized pacing and scaffolds praised by 78%, yet unmediated use offloaded critical thinking overreliance warnings; high multimodal integration and verbalization of AI's role coexisted with moderate revision, demanding teacher guidance for balanced autonomy. Past studies align: Lee (2025) and Rahman (2024) mirror valuing scaffolds yet wariness of passivity [67] [67]; Sarawak public pupils favour translanguaging for comprehension [69]. Reflexively, as Malaysian TESL researcher, findings underscore scaffolding evolution from tool-reliance to strategic agency.

These perceptions demand contextual professional development—AI literacy workshops, rural infrastructure, integrated metacognitive prompts, peer training—to sustain autonomy in Industry 4.0 ESL, ensuring equitable digital translanguaging amid PISA declines.

5.4 Limitations

Despite its promising potential, Google Translate- assisted translanguaging presents several inherent limitations. Large language models, such as Google Translate and generative AI systems, operate primarily on statistical probabilities derived from static data sets, which often fail to capture the dynamic, context-specific, and sociocultural nuances inherent to multilingual classrooms [76]. This results in semantic inaccuracies and a potential lack of inclusivity for emergent minority or marginalized linguistic practices [77]. The research highlighted risks of automation bias and cognitive offloading, where learners might over trust AI outputs without adequate critical engagement, thereby impeding development of metacognition and independent language skills [78].

Additionally, infrastructural and digital inequities remain pronounced in rural Malaysian settings, restricting AI accessibility and consistent application [38]. The small purposive sample size (n=4 Year 6 ESL students at CEFR Band 3-4) limits transferability of findings to broader populations, though triangulation across observations, interviews, and artifacts strengthens credibility within this rural case context. Variability in digital literacy levels among students and teachers further complicates effective deployment, demanding comprehensive professional development and learner training that were beyond this study's scope [38]. Ethical concerns related to privacy, data security, and the hidden biases embedded in extensive language models necessitate ongoing vigilance and responsible AI use frameworks [79].

5.5 Future Recommendations

Future research and practice should focus on developing pedagogical frameworks that actively integrate translanguaging as a critical analytical tool for navigating and mitigating AI's limitations [76]. Educators should be equipped with specialized training to scaffold metacognitive awareness and digital literacy, emphasizing learner autonomy and critical technology use. Curricular reforms are necessary to embed AI literacy comprehensively within ESL education, ensuring balanced digital translanguaging strategies that blend AI assistance with traditional language learning methods [38].

Efforts to bridge digital divides are crucial; investments in infrastructure, broadband access, and equitable device distribution must accompany pedagogic innovations to ensure all learners harness AI's benefits fairly. Research exploring diverse Google Translate-assisted educational contexts, especially longitudinal studies tracking metacognitive growth and language outcomes, will provide nuanced insights to refine digital translanguaging integration strategies.

Moreover, interdisciplinary collaborations among linguists, AI developers, educators, and policymakers can foster AI tools culturally adapted to diverse multilingual realities. This may involve designing generative AI models responsive to linguistic flux and emerging sociocultural discourses, aligning with translanguaging's fluid and inclusive pedagogical stance [77].

6. Conclusion

This study concludes that rural Malaysian primary case advances AI-assisted translanguaging by demonstrating its viability for CEFR Band 3-4 ESL readers amid infrastructural inequities, where monolingual methods falter. Unlike prior urban or secondary studies focused on general digital benefits, this work extends the literature through a phased implementation model that systematically scaffolds comprehension via Google Translate, uncovers context-specific AI pitfalls like translation inaccuracies and cultural mismatches, and captures nuanced positive perceptions under teacher mediation—directly addressing gaps in resource-poor primary settings aligned with national PISA reading declines.

Synthesizing findings across research questions, "critical translanguaging" emerges as the core theoretical and pedagogical insight: a balanced approach integrating AI's real-time immediacy with deliberate metacognitive prompting. This counters overreliance risks, automation bias, and cognitive offloading while fostering higher-order thinking skills (HOTS) and learner autonomy—innovations absent in existing digital translanguaging frameworks that emphasize broad affordances without rural-specific mediation strategies.

Policymakers should embed this model within MBBMMBBI frameworks through targeted rural teacher professional development modules emphasizing critical AI mediation, equitable access protocols, and ethical safeguards. Future multi-site, longitudinal trials across diverse Malaysian ESL

contexts will validate scalability, refine the observation checklist for broader adoption, and optimize AI tools for plurilingual equity, ultimately transforming literacy outcomes in multilingual classrooms

This study contributes to the growing evidence base supporting Google Translate- assisted translanguaging as a transformative educational technology in multilingual classrooms. It suggests that with equitable access, supportive pedagogy, and ethical AI use frameworks in place, these tools can significantly support language acquisition and literacy development, thereby enhancing educational outcomes in diverse and resource-constrained settings.

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