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English Grammatical Errors in Thai EFL Students' Paragraph Writing: An Analysis of Error Types, Causes, and Pedagogical Recommendations

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ABSTRACT

Grammatical accuracy remains a persistent challenge for Thai students learning English as a foreign language (EFL), particularly in written production. This study aimed to (1) examine the types and frequency of grammatical errors in English paragraph writing produced by 62 Grade 12 Thai EFL students at a public secondary school in Chonburi, Thailand, and (2) explore the underlying causes of these errors from learners' perspectives. Using an error analysis framework, a total of 1,016 grammatical errors were identified and classified into 14 categories. The most frequent errors involved article usage (22.44%), verb tense (12.99%), subject-verb agreement (12.60%), singular/plural noun forms (8.66%), and prepositions (7.87%). To investigate the causes of these errors, focus group discussions revealed four key factors: linguistic differences between Thai and English, overgeneralization of grammatical rules, reliance on direct translation, and limited exposure to grammar in authentic contexts. Based on these findings, the study recommends the use of contrastive analysis activities, targeted corrective feedback, and contextualized grammar instruction to enhance grammatical accuracy in secondary-level EFL writing. The results contribute pedagogical insights for teachers, curriculum designers, and teacher education programs in Thailand.

Keywords: Grammatical Errors, Thai EFL Students, Paragraph Writing, Error Analysis, Second Language Acquisition

Introduction

English language has become a pivotal vehicle in the era of globalization, functioning as a key mediator for global interaction in fields including education, business, and technology. In Thailand, where English functions as a foreign language, English language proficiency plays a crucial role in enabling students to pursue higher education and improve their career prospects. Among the core language competencies, writing is widely regarded as a fundamental skill for academic and professional success (Laksanasut, 2025). Acquiring competence in English grammar is especially significant to the formulation of organized paragraphs because grammatical accuracy helps facilitate increased clarity and cohesiveness (Darasawang & Watson Todd, 2020). However, many Thai secondary-level EFL students face challenges with the utilization of appropriate grammatical rules, and this negatively affects both the quality of their texts and their general linguistic ability.

Despite the major focus placed upon the acquisition of the English language within Thailand, Thai EFL students still face issues with grammatical accuracy within their paragraph writing. Common mistakes include the lack of the use of articles, the incorrect use of verb tenses, subject-verb agreement disparities, and incorrect prepositional placement. Most of these issues typically arise from the differences existing between Thai and English languages, grammatical rule overgeneralization, and the lack of adequate exposure to natural linguistic environments (Bucol & Sangkawong, 2025). Furthermore, reliance upon direct Thai-to-English translation contributes to syntactic errors, thus making it harder for the students to construct grammatically accurate sentences. The persisting problems point towards the need for a detailed analysis of students' grammatical errors to design precise interventions targeting the improvement of their writing proficiency.

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Despite several studies having touched on the English writing ability of Thai EFL students, very few have zoomed in on grammatical errors in paragraph writing at the secondary education level. Most of the existing studies have mainly concentrated on either overall writing difficulty or university-level students, thus creating an unsettled section in relation to the grammatical difficulties faced by students at the secondary level (Noite, 2025). It is vital to unearth the particular grammatical error categories and causes faced by these students to develop efficient pedagogical solutions and bolster curriculum structures. The current research attempts to close this established gap through the organized examination of widespread grammatical errors in paragraph writing and their causality. A recent study pinpointed the ongoing issues faced by Thai EFL students with the acquisition of English grammar. Manok and Thienpermpool (2021) identified lexical errors within paragraph writing by first-year university students as most common, including the errors of confusion between parts of speech, omitted words, and incorrect preposition usage. Kampookaew (2020), too, found the most common errors for university students were related to nouns, omitted article usage, subject-verb agreement errors, and incorrect classification of word type. Sonthirak et al. (2020), within a corresponding study, identified the most common grammatical and structural errors within the writing of paragraphs by undergraduate English major students as verb form errors, word misuse, and prefix errors. The studies identify the need to investigate grammatical issues within writing at the secondary level and determine the most appropriate pedagogical interventions for the acquisition of writing proficiency.

Despite extensive research on grammatical errors in Thai EFL contexts, most existing studies have focused predominantly on tertiary-level learners and have relied largely on quantitative classifications of error types. As a result, limited attention has been given to secondary-level students, whose interlanguage systems are still developing and may be more responsive to pedagogical intervention. Furthermore, many previous studies have examined error frequencies without systematically exploring learners' own perceptions of why such errors occur. This study addresses these gaps by focusing on secondary-level EFL learners and by integrating quantitative error analysis with qualitative focus group discussions. By examining both error patterns and learner-perceived causes, the study provides a more comprehensive understanding of grammatical difficulties at an earlier stage of language development and offers pedagogically relevant insights for secondary English instruction.

Literature review

Recent studies have provided deeper insights into the persistent grammatical challenges faced by Thai EFL students in writing, particularly in the context of secondary education. Researchers have noted that errors such as article omissions, verb tense inconsistencies, subject-verb agreement issues, and preposition misuse are not isolated phenomena; rather, they reflect underlying linguistic interference from the students' first language and limitations in instructional practices.

Kim (2024) reported that the direct transfer of grammatical structures from Thai into English has led to a high frequency of errors, especially regarding the use of articles and verb tenses. In Thai, where articles and tense markers are not required, students often struggle to internalize their usage in English. Noite (2025) extended this discussion by demonstrating that, despite recent curriculum reforms, Thai students continue to exhibit similar error patterns. These studies suggest that linguistic interference remains a critical factor affecting grammatical accuracy, as students frequently rely on their native language patterns when writing in English.

The application of traditional frameworks such as Error Analysis and Interlanguage Theory has been reexamined in the context of modern classroom environments. Sabrina et al. (2025) observed that overgeneralization of English grammatical rules leads students to apply rules in inappropriate contexts—for instance, adding articles unnecessarily or mispluralizing nouns. Their study emphasizes that without clear instruction on exceptions and rule limitations, students remain prone to error. In contrast, Lang et al. (2024) highlighted that context-based instruction and corrective feedback can substantially reduce these error rates. Their quasi-experimental study demonstrated that when students engage with authentic language input—through both reading and guided writing practice—the incidence of grammatical errors diminishes significantly.

Furthermore, Bucol and Sangkawong (2025) argued that integrating contrastive analysis into language instruction helps students become more aware of the structural differences between Thai and English. By explicitly comparing the two languages, teachers can help learners understand why certain grammatical features appear in English but not in Thai. This method has been shown to improve students' grasp of grammatical nuances and to mitigate the negative effects of linguistic interference.

Recent institutional reports, such as those from Angsilapittayakom School (2024) and The Office of the Secondary Education Service Area Chonburi – Rayong (2024), further support the need for innovative instructional strategies. These reports recommend longitudinal studies and cross-regional research to capture the evolving nature of EFL writing proficiency. They also call for enhanced teacher training programs that focus on modern pedagogical techniques, including task-based learning and extensive corrective feedback.

Overall, the literature published since 2022 underscores that while traditional errors persist, modern teaching practices and contextualized learning environments show promise in addressing these issues. The convergence of recent empirical studies suggests that a multifaceted approach—combining contrastive analysis, authentic language exposure, and ongoing formative assessment—is essential for reducing grammatical errors in Thai EFL writing.

Research Objectives

- 1 To investigate the English grammatical errors in paragraph writing among Thai EFL secondary-level students.
2. To explore the root causes behind grammatical errors in the construction of paragraphs by Thai EFL secondary students.

Research Questions

1. What are the most common grammatical mistakes found within English paragraph writing by Thai secondary EFL students?
2. What are the causes of grammatical errors in paragraph writing among Thai EFL students at the secondary level?

Research framework

The first aim of the current study was the exploration of two major aspects: the varieties of grammatical errors found within the paragraphs written by Thai EFL students and the causes behind the errors. Theoretical backings for this study were the theories of Error Analysis and Interlanguage.

1. Grammatical Errors (Dependent Variables): The study recognized errors according to the Error Analysis Model put forth by James (1998) and Norrish (1987), which categorized these errors into 14 different categories: articles, tenses, conjunctions, prepositions, auxiliaries, word forms, singular/plural nouns, pronouns, word order, subject-verb agreement, infinitives, relative clauses, word choices, and the use of "there + be."
2. Causes of Errors (Independent Variables): The study identified a number of causes behind the occurrence of errors as found during the Focus group discussion (FGD): (1) Linguistic Disparities: The inherent structural differences between English and Thai, illustrated by the lack of articles and the non-inflection of verb tense for Thai, resulted in common mistakes; (2) Overgeneralization: The tendency towards the unselective use of English grammatical rules, including the use of inappropriate ones, caused incorrect usage of articles and pluralization among others; (3) Literal Translation: The process of word-for-word translation from Thai into English oftentimes resulted in incorrect word sequence and misuse of prepositions; and (4) Lack of Exposure to Contextualized Grammar: The opportunity for actual interaction or contextual practice with English grammar was not provided, resulting in difficulties towards the actual usage of grammatical principles when writing.

3. Theoretical Background: The study is based upon the core principles of the theory of Error Analysis (Corder, 1967) and Interlanguage Theory (Selinker, 1972). Error Analysis deals with the identification, classification, and study of the errors made by the students when using the target language. Interlanguage Theory assumes that the students pass through certain transitional stages between the target and their mother language and thus make errors influenced by the two languages.

4. Theoretical Framework: Error Analysis and Interlanguage Theory: This study is grounded in Error Analysis (Corder, 1967; James, 1998) and Interlanguage Theory (Selinker, 1972), which together provide the conceptual lens for examining learner language. Error Analysis enables the systematic identification and classification of grammatical errors, allowing researchers to determine patterns that reflect learners' developing linguistic systems rather than random mistakes. Interlanguage Theory further explains these errors as evidence of a transitional linguistic system influenced by both the learner's first language and the target language.

While previous Thai EFL studies have often applied error analysis descriptively, they have seldom connected error patterns to learners' cognitive and experiential explanations of those errors. By integrating FGD into the research design, the present study extends these theoretical frameworks by examining how linguistic interference, overgeneralization, and limited contextual exposure shape students' interlanguage development. Thus, the selected theories not only inform the classification of errors but also guide the interpretation of their underlying causes.

Research methodology

Research Design

This study employed an explanatory sequential mixed-methods design to address the research objectives comprehensively. Quantitative data were first collected through error analysis of student writing samples to identify patterns and frequencies of grammatical errors. Subsequently, qualitative data were gathered through FGDs to explore the underlying causes of these errors from students' perspectives. This design was appropriate because grammatical error patterns alone cannot fully explain why learners continue to make such errors; qualitative insights are necessary to interpret learners' linguistic reasoning, learning experiences, and contextual constraints. The study procedures are explained as follows.

Population and Sample

The population consisted of 426 EFL secondary-level students enrolled in the first semester of the academic year 2024 at a public secondary school in Chonburi, Thailand (Angsilapittayakom School, 2024; The Office of the Secondary Education Service Area Chonburi - Rayong, 2024).

The research sample consisted of 62 Grade 12 students who are English as a Foreign Language (EFL) students and were selected through a multi-stage sampling technique (Phomjui, 2020) to ensure both representativeness and freedom from bias in the selection of the sample. The sampling process consisted of multiple steps: First, Simple Random Sampling was applied in selecting the grade level relevant to the study, resulting in the selection of students from Grade 12. Then, Cluster Random Sampling was applied, where classrooms served as the units of selection. Two out of four available classrooms were randomly selected, yielding a final sample of 62 students. All the participants in the study were native Thai speakers who had studied the English language for at least 10 years. At the time of data collection, these students were enrolled in an elective course called English for Tourism Industry, which aims to develop students' abilities to communicate effectively in English on tourism-related topics, both in verbal and non-verbal communication.

Research Instruments

1. The Student Writing Samples consisted of the English paragraph-writing tasks done by 62 Grade 12 EFL students from a public secondary school in Chonburi, Thailand, during the first semester of the 2024 academic year. These writing samples were derived from the students' final exam, specifically from Part 2: Writing Section (200–250 words), which aimed to assess their writing ability. In this section, students were instructed to write a paragraph-length essay on a tourist spot in Chonburi Province. The instructions asked students to describe the location of the chosen tourist spot, explain

its importance or appeal, provide recommendations for planning a visit, describe the route to take from their school to the site, and justify their selection of the tourist spot. The researcher chose to analyze the Writing Section because it focused on vocabulary use in English paragraph writing. Additionally, the students submitted their writings as part of the exam without prior revision, correction, or feedback from instructors. The practice ensured the samples reflected the students' true vocabulary selection and use, making them suitable for error analysis. While the researcher had previously examined the students' grammatical errors, that investigation largely concentrated on grammatical concerns and did not systematically classify the types of errors. As such, this study aimed to conduct a fuller lexical error analysis, systematically classifying specific vocabulary-related errors to gain a clearer and more detailed picture of students' writing challenges. Before data collection began, informed consent was obtained from both the students and the school administration to use the writing samples for research. The writing samples were selected as the primary data source because they provide direct evidence of students' grammatical competence in extended written discourse, allowing for systematic identification of grammatical errors related to sentence structure, verb forms, agreement, and function words. All ethical standards relating to student privacy and confidentiality were strictly adhered to.

2. A Systematic Error Log Sheet was used to record the different grammatical mistakes found in the English paragraph writing done by each student. The log was modeled after the Error Analysis Framework developed by James (1998) and Norrish (1987), who divided grammatical errors into fourteen different categories: (1) Articles, (2) Tenses, (3) Conjunctions, (4) Prepositions, (5) Auxiliaries, (6) Word Forms, (7) Singular and Plural Nouns, (8) Pronouns, (9) Word Order, (10) Subject-Verb Agreement, (11) Infinitives, (12) Relative Clauses, (13) Word Choices, and (14) Use of "There + Be." The log allowed the recording of frequencies within the categories, thus establishing a quantitative image of the errors made by the students' written work. The Error Log Sheet was used to study 62 English paragraph-writing samples from Grade 12 EFL students who attended a government high school located in Chonburi, Thailand, during the first semester of the academic year 2024. Through the computation of the frequency and percentage for each type of mistake, the log provided valuable information about the frequency and patterns of grammatical, structural, spelling, and punctuation mistakes found within the written work done by the students.

3. A FGD was used to explore the root causes for grammatical errors made while writing paragraphs by Thai EFL secondary students. FGDs were selected instead of individual interviews because they allow participants to interact, compare experiences, and collectively construct meanings related to their writing difficulties. This interactional context is particularly valuable for exploring shared learning experiences, classroom practices, and common grammatical challenges among students. The FGD was based on a sequence of five open-ended questions, which were established through a critical review of the literature, empirical findings, and conceptual frameworks. To ensure the questions were clear and pertinent, the study relied on the advice of experts and edited the wording where appropriate. The refined questions were piloted with a group of non-participant students with the aim of pinpointing necessary changes before their usage within the primary study. A purposive sampling approach was used for the selection of 20 students from the total sample with the goal of obtaining qualitative data. The discussion occurred within the span of four sessions with each session involving five participants and thus providing an interactive platform where each student could voice their opinions. The purpose of the FGD was to get insights from the students about the difficulties faced by them while writing English paragraphs, their educational backgrounds, and the probable reasons behind their grammatical errors. The qualitative data collected provided valuable information related to the sources of the errors, thus complementing the findings gained through the written assignments.

Data collection

The data collection process was conducted in two phases: analysis of student writing samples and a FGD. Writing samples were obtained from 62 Grade 12 EFL students from a public secondary school in Chonburi, Thailand, during the first semester of the 2024 academic year. The writing samples, which were derived from the writing component of the final exam, were analyzed using the Error Analysis Framework suggested by James (1998) and Norrish (1987) in order to categorize grammatical errors into 14 categories. Errors were recorded in an Error Log Sheet to determine their

frequency and distribution. To complement the investigation of the underlying reasons for such errors, an FGD was carried out with 20 students who were chosen purposively. Four sessions, each comprising five participants, probed the students' views on grammatical difficulties through the administration of structured open-ended questions. A conclusion-oriented data analysis approach was used to determine notable patterns and contributing factors. This systematic approach allowed for an in-depth understanding of the grammatical difficulties faced by Thai EFL students.

Data analysis

1. Analysis of Student Sample Writings Data: The sample writings of sixty-two students consisting of about 12,834 words were examined through the perspective of the Error Analysis Framework formulated by James (1998) and Norrish (1987) with the intention of analyzing grammatical errors. The essays were first thoroughly analyzed through word-by-word and sentence-by-sentence scrutiny. The errors were identified and systematically registered in the Error Log Sheet with different categories of grammatical mistakes usually found in writing paragraphs and their respective frequencies. The categorization process was done following the frameworks outlined by James (1998) and Norrish (1987). The findings were synthesized through the juxtaposition of the frequency of each grammatical error type found within the writings of the students. The prevalence of each type was measured as a percentage value, and the errors were ranked based on their frequency level of occurrence from most common to least common. The findings were expressed through percentages, frequencies, and rankings and thus explained the prevalence of grammatical mistakes within the student sample writings.

2. Analysis of FGD Data: The researcher used a conclusion-led approach for analyzing the qualitative data gathered through the FGDs. The first step within the data analysis process was Data Reduction, where the raw data were reduced into critical summaries. Then the findings were expressed by the researcher with the aid of highlighting the chief data elements related to the study identified during the FGD. Finally, the researcher made Conclusion and Verification where minor findings were synthesized into a complete summary and verified these findings as the authoritative results of the study (Klangphahol, 2020).

Results

This section fully reported the findings from the analysis of grammatical errors in English, as found in the paragraph writing of Thai EFL students. It also reported on the findings from FGDs with the students, covering each of the two research questions posed at the beginning of this research.

Research question 1: What are the most common grammatical mistakes found within English paragraph writing by Thai secondary EFL students?

English grammatical errors made by 62 Thai EFL secondary students who joined this study were categorized into 14 categories. The most frequent category was errors concerning the use of articles, with a total of 228 errors, representing 22.44% of the total errors found (see Table 1). The second most common category was errors related to verb tenses, with 132 instances (12.99%), closely followed by errors related to subject-verb agreement, totaling 128 errors (12.60%). In addition, singular and plural errors were also common, totaling 88 errors (8.66%), ranking as the fourth most frequent category. Moreover, errors involving prepositions and word order were equally frequent, each totaling 80 errors (7.87%).

Errors involving conjunctions were 52 occurrences (5.12%), while auxiliary verb errors were not very frequent with 44 occurrences (4.33%). Word form errors (40 occurrences, 3.94%) were also very notable as were relative clause errors (36 occurrences, 3.54%) and errors involving pronouns (36 occurrences, 3.54%). Furthermore, infinitive errors were reported with 32 occurrences (3.15%), while word choice errors (24 occurrences, 2.36%) and "there + be" misuse (16 occurrences, 1.57%) were the least frequent. Overall, 1,016 grammatical errors were found occurring within students'

writing paragraphs and highlighting the need for instructional interventions with focus towards tackling these ongoing issues.

Table 1 *Types, Percentages, and Ranks of Errors in Paragraph Writing of Thai EFL secondary-level students*

Types of Grammatical Errors	Frequency	Percentage	Rank
Articles	228	22.44	1
Tenses	132	12.99	2
Subject-Verb Agreements	128	12.60	3
Singular and Plural Nouns	88	8.66	4
Prepositions	80	7.87	5
Word Order	80	7.87	6
Conjunctions	52	5.12	7
Auxiliaries	44	4.33	8
Word Forms	40	3.94	9
Relative Clauses	36	3.54	10
Pronouns	36	3.54	11
Infinitives	32	3.15	12
Word Choices	24	2.36	13
The Use of There + Be	16	1.57	14
Total	1016	100	14

The following were the five most common grammatical errors found within the writings of students: article omission, incorrect verb tense, subject-verb agreement errors, singular and plural noun errors, and preposition misuse.

1. Article Omission:

".....Bangsaen Beach is famous tourist attraction in Chonburi....."

The first sentence demonstrated the absence of the article "a" before "famous tourist attraction." This type of error is quite common among Thai students, as the Thai language does not use articles like English. Similarly, the absence of "the" before "beach" in the second sentence below showed difficulty in distinguishing between the correct contexts of using definite and indefinite articles.

2. Incorrect Verb Tense:

".....I went to Angsila subdistrict last weekend and stay at the hotel near beach....."

This second example also demonstrated inconsistency in the use of verb tense. The verb "stay" must be translated into the past tense verb "stayed" to be consistent with the temporal adverb "last weekend." Thai verbs are not modified with respect to tense; therefore, students often get confused when incorporating the past tense markers into their English writing.

3. Subject-Verb Agreement:

".....The Angsila Old Market have many wooden houses....."

The third sentence had the incorrect subject-verb agreement. As "The Angsila Old Market" is a singular noun, the verb must also be "has" instead of "have." The verb does not change regardless of the singular or plural nature of the subject in Thai language, a feature which most English students find confusing as there is no need for the verb to change here.

4. Singular and Plural Noun Usage:

".....There are many beautiful temple in Chonburi, but Wat Angsila is the most famous....."

The above statement demonstrated inconsistency with the use of singular and plural nouns. The word "temple" should be used in the plural context ("temples") for agreement with the quantity word "many." There is no clear distinction between singular and plural nouns within the Thai grammatical

structure as used in English since plural markers are used very seldom in informal communication and writing. Thai English foreign language students therefore often misuse singular nouns where two or more items are involved. The misuse was most common within written essays by students and demonstrated difficulties within the acquisition of English pluralization rules.

5. Preposition Misuse:

".....I went to Angsila Fishing Village last weekend and swam in the sea on the morning....."

The original sentence contains a preposition usage mistake. Precisely, the phrase "on the morning" needs to be adjusted to "in the morning" because English prepositions follow conventional collocations different from Thai. Thai prepositions function differently within the Thai language and are either omitted or used with markers based upon context. The variation results very often in mistakes made by Thai students who try to use English prepositions based directly upon their mother language. Since prepositions are not always directly equivalent within Thai usage, students face the challenge of properly selecting the correct ones within their writing.

The errors identified showed that students largely rely on direct translation from Thai, which leads to structural inaccuracy. The findings aligned with the distribution of errors in the study, where the most common errors in the paragraph writing of the students involved omissions of articles, wrong verb tenses, subject-verb agreement, errors associated with singular and plural nouns, and incorrect use of prepositions.

Research question 2: What are the causes of grammatical errors in paragraph writing among Thai EFL students at the secondary level?

The findings drawn from the FGD regarding the causes of grammatical errors in Thai EFL students' writing paragraphs revealed some salient features. Below are the summary and discussion drawn from the FGD results:

1. Linguistic Differences between Thai and English

Across all four FGDs, students consistently identified structural differences between Thai and English as a major source of grammatical errors in their paragraph writing. In each group, the discussion began with students noting that Thai does not require articles or verb tense inflections, which led several participants to agree that they often omit these forms when writing in English. As students shared their experiences, others built on these comments by explaining that they were unsure when articles such as a or the were required, even if they were aware of the grammatical rules.

In Group 2, for example, one student pointed out that articles do not exist in Thai, prompting multiple peers to express similar difficulties. Another participant added that verb tense errors frequently occurred because Thai verbs do not change according to time, a view that was met with agreement from other group members. This collective discussion suggests that article omission and verb tense inconsistency are not isolated individual errors, but shared challenges shaped by first-language interference.

The convergence of views across the focus groups indicates that linguistic differences between Thai and English strongly influence students' interlanguage development, particularly in relation to grammatical features that are absent in their first language.

2. Overgeneralization of English Grammar Rules

Across all FGDs, students collectively reported that overgeneralization of English grammatical rules contributed significantly to errors in their paragraph writing. In each group, students explained that once they learned a grammatical rule, they tended to apply it broadly without being aware of exceptions or contextual constraints. This issue frequently arose during discussions about article usage and pluralization, with several participants acknowledging that they assumed consistent rule application would lead to correct sentences.

In Group 1, one student remarked that adding the before nouns made sentences feel “more complete,” which prompted other participants to agree and share similar strategies they used while writing. As the discussion progressed, students reflected on how teachers’ feedback often pointed out that such usage was incorrect, yet they remained uncertain about when the rule should or should not be applied. Another student added that plural markers were often attached automatically, leading to errors such as irregular plural forms. This comment was met with agreement from other group members, who described experiencing similar confusion.

The interaction among participants indicates that these errors stem not from a lack of grammatical knowledge, but from an incomplete understanding of rule limitations. The shared nature of these experiences across groups suggests that overgeneralization reflects a common developmental feature of students’ interlanguage, where partial rule acquisition leads to systematic but inappropriate grammatical application.

3. Reliance on Direct Translation

Reliance on direct word-for-word translation from Thai to English emerged as another prominent theme across the FGDs. In all groups, students described beginning the writing process by formulating sentences in Thai and then translating them into English, often without considering differences in sentence structure or grammatical requirements between the two languages. When one student raised this point, others readily agreed, noting that this strategy felt natural and efficient, particularly during timed writing tasks.

In Group 3, a student explained that prepositions were often omitted or incorrectly used because they were not required in the original Thai sentence. This observation led other participants to confirm that they frequently wrote sentences that “sounded correct” to them but were later marked as incorrect by teachers. As the discussion continued, students collectively recognized that literal translation often resulted in unnatural sentence structures, especially in expressions of movement, time, and location.

The group interactions reveal that direct translation is not merely an individual habit but a shared coping strategy adopted by students when they lack confidence in constructing English sentences independently. This co-constructed understanding highlights how first-language reliance shapes grammatical errors, particularly in areas where Thai and English differ syntactically.

4. Limited Exposure to English Grammar in Context

Students across all focus groups consistently emphasized that limited exposure to English grammar in meaningful contexts contributed to their persistent grammatical errors. During the discussions, participants frequently contrasted learning grammar rules in isolation with the difficulty of applying those rules during actual writing tasks. When one student mentioned memorizing grammar rules without opportunities to use them, several others expressed agreement and shared similar classroom experiences.

In Group 4, students discussed how grammar instruction was often focused on completing exercises or preparing for examinations rather than practicing grammar through reading, writing, or communicative activities. One participant commented that although they could recall rules during tests, they struggled to apply them when composing paragraphs. Other students responded by agreeing and adding that limited exposure to English outside the classroom, such as reading books or watching English media, further reduced their confidence in using grammar naturally.

The convergence of views across the focus groups suggests that insufficient contextualized practice prevents students from fully internalizing grammatical structures. This shared perception underscores the importance of providing learners with more opportunities to encounter and apply grammar in authentic communicative contexts, thereby supporting more effective interlanguage development.

Grammatical errors in paragraph writing among Thai EFL secondary-level students can be linked to a number of key factors. First, linguistic interference from the Thai language, which lacks articles and inflection of verb tenses, has led to omissions and incorrect usage of grammatical forms in English. Second, students often overgeneralized English grammatical rules, incorrectly applying them to different contexts, such as inserting "the" before every noun or incorrectly marking plural nouns. Third, reliance on direct translation from Thai to English has created sentence structure and preposition errors. Finally, a lack of exposure to English grammar in contextual structures has prevented students from fully internalizing grammatical rules, making it difficult for them to apply the rules during writing activities. These factors highlight the need for greater grammar instruction, corrective feedback, and greater exposure to English in authentic contexts.

Discussion

The aims of this study were to explore common grammatical errors in paragraph writing among Thai secondary EFL students and to investigate the root causes leading to such errors. The following is a discussion of the findings.

The high overall level of organizational climate indicates that administrators and teachers in schools under the Secondary Educational Service Area Office Chonburi-Rayong generally experience positive working environments characterized by trust, support, and effective communication. In particular, warmth and support emerged as the highest-rated dimension, suggesting that interpersonal relationships and professional support are central features of school life. This finding aligns with contemporary educational leadership research, which emphasizes that supportive leadership and positive social interactions contribute to teachers' well-being, job satisfaction, and professional commitment (Kanchanawongpaisan et al., 2026; Nguyen et al., 2026). A climate that promotes psychological safety enables teachers to perform their duties confidently and engage more actively in professional learning activities.

1. Grammatical Errors in Thai EFL Students' Writing

Findings derived from the current study are consistent with the results of recent studies concerning grammatical errors in English writing made by Thai EFL students. Manok & Thienpermpool (2021) investigated lexical errors and found common issues including parts-of-speech confusion, omissions, and misuse of prepositions among first-year university students. The misuse of prepositions emerged as one of the most common mistakes made under this context, reflecting a common challenge faced by Thai students in acquiring this particular dimension of English grammatical structure. Kampookaew (2020) found the deletion of articles, subject-verb agreement errors, and word-related errors were common issues among Thai university students, reflecting the findings outlined here. Specifically, deletion of the article and subject-verb agreement errors were two common mistakes made by Thai secondary-level students. This finding reflects the ongoing prevalence of such mistakes across different educational phases within Thailand. Along the same lines, Sonthirak et al. (2020) explored grammatical mistakes made when writing paragraphs and found verb

form errors, inappropriate word selection, and prefix errors were made by undergraduate students. The current study also found mistakes made with verb tense were a common problem, thus reflecting the fact that tense-related errors are a common barrier for Thai EFL students. The findings support the need for further examination into the continuing grammatical issues associated with Thai EFL students and the need to resolve these issues across different educational phases. The recurrent nature of the mistakes found within the current study as well as the mistakes found within the writing of university students also indicates the possibility that such issues may not be adequately addressed within previous educational phases.

2. Causes of Grammatical Errors

The study also outlined several main causes of grammatical errors, which align with current academic discussion in the field of second language acquisition. One particularly significant cause that was found was linguistic interference, specifically the lack of certain grammatical components in Thai, including articles and verb tense inflections. This finding supports the claims presented by Manok and Thienpermpool (2021), who explained that the lack of certain features unique to the English language within the Thai linguistic structure results in common errors, such as the omission and incorrect use of articles. In the present study, students' difficulties with the correct use of verb tenses were explained by the lack of tense inflections in their mother tongue, a phenomenon also investigated by Sabrina et al. (2025), who concluded that EFL students whose mother tongue does not mark tense struggle with this grammatical feature in English. Another substantial source of error found in this research was overgeneralization of grammatical rules in English. According to Kampookaew (2020), Thai EFL students have the tendency to overapply English grammatical rules, especially those related to the use of articles and plural forms. This tendency for grammatical overextension, demonstrated in this research through the unnecessary addition of articles and pluralization mistakes such as "childs" instead of "children," is consistent with Corder's (1967) findings on overgeneralization in language acquisition. The study also demonstrated that reliance on direct translation from Thai to English was a major source of grammatical errors, especially in the use of prepositions. The results reported by Kim (2024) are consistent with the results of the current study, where it was found that direct translation tended to produce structural and preposition errors. The students participating in the current study admitted adopting a word-for-word approach to translating from Thai into English with the consequence of producing structural errors and misuse of prepositions. The errors are a testament to the clear structural differences between Thai and English, since the use of prepositions varies extremely between the two languages. Students further attributed their grammatical errors to a lack of exposure to English grammar in contextualized environments. This claim is supported by Hutchins et al. (2024), who pointed out the pivotal nature of context-based acquisition towards the maintenance of grammatical rules. Lack of interaction with authentic English environments either through reading practice or actual conversation hindered students' ability to internalize grammatical principles and apply them effectively.

The persistence of grammatical errors despite long-term exposure to English instruction raises critical questions about the effectiveness of prevailing grammar teaching practices in Thailand. While students are often taught grammatical rules explicitly, limited opportunities to apply these rules in meaningful contexts may hinder interlanguage development and contribute to fossilisation. From an interlanguage perspective, the findings suggest that students' grammatical systems stabilise around incomplete or inaccurate forms when corrective feedback is infrequent or non-specific. This underscores the need to reconsider how grammar is taught, assessed, and reinforced across secondary education.

This study contributes to the existing literature by shifting the analytical focus from error classification alone to an integrated examination of error patterns and learner-perceived causes at the secondary level. By foregrounding students' voices through FGDs, the study provides insight into how instructional practices, linguistic transfer, and limited contextual exposure jointly shape grammatical development. These findings extend previous Thai EFL research and offer pedagogically actionable knowledge for early intervention before errors become fossilised at higher educational levels.

Conclusion

This study has revealed that grammatical errors in paragraph writing among Thai secondary EFL students predominantly manifest as article omissions, verb tense inconsistencies, subject-verb agreement issues, and incorrect preposition usage. The quantitative analysis underscored the high frequency of these errors, while the qualitative insights illuminated the main underlying factors—including linguistic interference, overgeneralization of English rules, reliance on direct translation, and limited contextual exposure.

The findings underscore the need for targeted instructional strategies. Enhanced corrective feedback, the incorporation of contrastive analysis, and context-based teaching methods emerge as promising approaches to mitigate these errors and improve overall writing proficiency. Moreover, the study highlights the importance of future research employing longitudinal and multi-regional methodologies to better capture the dynamic nature of EFL writing development and to refine pedagogical interventions further.

Recommendations

Recommendations for Applying Research Findings

1. Teachers are encouraged to implement contrastive analysis activities that explicitly compare Thai and English grammatical structures. For example, short sentence-comparison tasks can be used to highlight the absence of articles and tense inflections in Thai and their obligatory use in English. Corrective feedback should be timely and focused, combining direct written feedback on recurrent grammatical errors with brief oral explanations during writing revision activities.

2. At the institutional level, teacher education programs should incorporate training on interlanguage development and error-informed instruction, enabling teachers to diagnose persistent grammatical patterns and respond with targeted pedagogical strategies. Curriculum designers may also consider integrating contextualized grammar tasks into secondary English syllabi to reduce the gap between rule knowledge and actual language use.

Recommendations for Future Research

1. Expand the Study into Further Regions: The implications of this study can be further extended through subsequent studies into the areas of grammatical errors with EFL students in other parts of Thailand or other countries where English is a foreign language. This would enable a deeper understanding of the common grammatical mistakes found within EFL environments.

2. Longitudinal Studies of the Development of Error: Longitudinal studies tracking the development of grammatical errors through time would yield valuable insights into the change in grammatical ability in students and reveal the most successful strategies for improvement.

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Pre-service Teachers' Perceptions of Dual-Role Peer Feedback in English Presentation: The APPLE Model Approach

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ABSTRACT

Peer feedback is a vital pedagogical tool in teacher education, yet its implementation often faces psychological and structural challenges. This study investigates the perceptions of pre-service teachers regarding their dual roles as 'feedback providers' and 'feedback receivers' within the context of English presentation skills. To facilitate this process, the study introduces the APPLE Model (Acknowledging, Practicing, Performing, Laying Feedback, and Evaluating Feedback) as a structured framework rooted in Kolb's Experiential Learning Theory and Rogers' Feedback Theory. The research also sought to identify the most favorable types of feedback among participants based on Rogers' categories. The participants were twenty-six English major pre-service teachers at a public university in Northeastern Thailand, selected through purposive sampling. Data were collected via a comprehensive questionnaire and analyzed using descriptive statistics and thematic analysis. The findings revealed that participants highly valued the feedback process, with a stronger preference for the role of feedback receiver over provider. Notably, 'Supportive Feedback' emerged as the most preferred category (45%), described by students as being 'honest yet soft for the heart,' providing essential emotional scaffolding alongside constructive guidance. While the participants acknowledged the benefits of diverse perspectives, qualitative insights highlighted concerns regarding the perceived expertise of peer providers and the psychological pressure of direct critique. The study concludes that the APPLE Model effectively bridges the gap between theoretical knowledge and practical classroom application, serving as a significant template for enhancing reflective practices and professional communication skills in teacher training programs.

Keywords: Peer Feedback, Apple Model, Pre-Service Teachers, Experiential Learning, Rogers' Feedback Theory

Introduction

Once a person learns to give a presentation, s/he is expected to apply the skill for various purposes. It is considered a lifelong learning skill. Educational institutions strive to provide basic presentation knowledge to students, expecting that the skill will be beneficial in a real working environment. However, the learning process currently used in some classrooms might not be efficient in promoting proficient presentation skills. Many classes are taught using a 'teacher-centered' approach. In this setting, teachers play the primary role while students are considered 'passive learners' who listen and perform role plays according to instructions. Some teachers prefer this because it is controllable; nevertheless, this approach is not effective in helping students acquire the skill. Ahmed et al. (2022) stated that students are passive learners in teacher-centered approaches, which eliminates opportunities to enhance critical thinking and problem-solving. Additionally, being a passive learner may result in a lack of self-confidence. Students may find it difficult to present without direct instructions and may not know how to deal with unexpected situations. While students have their own ways of handling such situations, they may doubt their decisions since they have not been approved by teachers. Moreover, the teacher-centered approach provides little room for students to participate or assist each other, resulting in a lack of creativity in their learning process.

Presentation skills should not end after finishing a course; students should be able to apply them to various scenarios as a lifelong learning skill. Therefore, a presentation course must be carefully designed to provide enough opportunity for students to practice. So, what should the course be like? A 'student-centered learning approach' should be mentioned. This approach provides room for students to dominate the learning process as 'active learners'. Learning by practicing with various

scenarios increases students' confidence and stimulates their thinking skills when they are required to solve unexpected problems during a presentation.

However, some teachers may be concerned that allowing students to learn by themselves leads to weaknesses; some students may lack self-learning skills or be unfamiliar with this approach. To be honest, this concern is not beneficial for students expected to be independent learners. For teachers who do not know where to start, 'Peer Feedback' is introduced. 'Peer Feedback' refers to students helping each other in the learning process. They learn by watching and interacting with classmates under teacher monitoring. Li and Steckelberg (2004) stated that peer feedback promotes student autonomy and meaningful learning. They also claimed that achievement improves if students take an active role. After receiving feedback, students should consider and apply it to improve. The best way to value feedback is by applying it in a real scenario, an idea supported by 'Experiential Learning Theory' (Kolb, 1984). According to Kolb (1984), learning is the process whereby knowledge is created through the transformation of experience.

Regarding feedback, Hattie and Timperley (2007) refer to comments a person gets from others about their performance. Feedback can come from various agents such as instructors, classmates, or parents. For Hattie and Timperley (2007), learners can also provide feedback for themselves. Why is 'peer feedback' crucial? Compared to feedback in general, peer feedback provides opportunities to learn and interact in class. While general feedback might provide information, the receivers often act only as listeners. Meanwhile, peer feedback assigns students to be both 'feedback receivers' and 'feedback providers', which enhances interaction.

Within the landscape of contemporary English language pedagogy, effective communication and presentation skills are paramount for pre-service teachers. However, fostering these skills often necessitates active engagement through peer feedback, going beyond traditional teacher-led instruction. Despite its recognized benefits, many students struggle with the complexities of navigating their dual roles as both providers and receivers of constructive criticism. While previous studies have extensively explored peer feedback in general EFL contexts, a significant gap remains in providing a structured framework specifically within the pre-service teacher training in Thailand. To address this oversight, the present study proposes the APPLE Model (Acknowledging, Practicing, Performing, Laying Feedback, and Evaluating Feedback). Drawing upon Rogers' Feedback Theory (1961) and Kolb's Experiential Learning Theory, this model serves as a systematic pathway to illuminate how future teachers navigate the feedback process. By investigating these dual-role perceptions, this research aims to bridge the gap between theoretical feedback frameworks and practical classroom implementation.

The participants in this study are worth studying as they are pre-service teachers expected to work as professionals. In their career, they will certainly provide feedback through grading or student evaluations. Thus, they are expected to be proficient in both receiving and providing feedback. Developing feedback literacy and oral communication are not only parts of language learning but also core components of 21st-century skills. In the current educational landscape, pre-service teachers must be equipped to provide and process constructive criticism to foster collaboration. Therefore, this study investigates participants' perceptions toward 'peer feedback'. The results reflect their points of view and their perceptions regarding the significance of such feedback. Moreover, the results suggest types of feedback they consider useful. Knowing the effectiveness of each type can serve as evidence for both the researcher, as an instructor, and the participants, as pre-service teachers, in providing the right feedback in class.

The significance of focusing on pre-service teachers lies in their dual role as current learners and future instructional leaders. Unlike general ESL students, these participants are developing 'Feedback Literacy' - a critical professional competence. Understanding the nuances of different feedback types, such as 'Supportive' versus 'Evaluative,' enables them to cultivate a growth mindset in their future classrooms. By mastering the APPLE Model, they transition from being recipients of knowledge to becoming architects of constructive learning environments, where they can effectively model and

facilitate the feedback process for their own future students. Thus, this study serves not only as a language intervention but as a foundational step in professional teacher development.

Literature review

Experiential Learning

The 'Experiential Learning Approach' has been discussed for decades. Drummond (2003) noted that Carl Rogers (1902–1987) initially identified two major types of learning: cognitive and experiential. While cognitive learning involves memorization, experiential learning refers to applying knowledge gained through action. Despite its long history, this approach remains effective in helping students acquire knowledge by 'learning from experiencing' or 'learning by doing.'

Hedin (2010) distinguished between experiential learning, which refers to the 'process of learning,' and experiential education, which refers to the context or pedagogy applying that process. David Kolb (1984, 2005) further popularized this approach in the 1980s, emphasizing that learning occurs through action and the ability to apply tasks in various scenarios. Kolb's 'cycle of learning' consists of four stages:

1. Concrete Learning: Gaining actual experience with new skills or theories.
2. Reflective Observation: Questioning the experience to achieve learning goals and figuring out ways to apply observations elsewhere.
3. Abstract Conceptualization: Understanding causes, effects, and the logic behind a particular result.
4. Active Experimentation: Applying learned skills in new scenarios to test strengths and weaknesses.

Kolb's theory shares key principles with John Dewey's learning theory, as both promote a 'hands-on' approach. Dewey argued that learning occurs when a person is involved in a learning environment or specific task scenarios. Both theorists agree that this 'hands-on' approach applies to laboratories, field trips, and project-based or problem-based learning. However, the teacher remains crucial as a facilitator who sets clear learning objectives to design an appropriate environment.

Bloom's Taxonomy: The Revised Taxonomy

The original taxonomy, introduced by Benjamin Bloom in 1956, organized learning into six categories: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Armstrong (2010) noted that the 2001 revised version, 'A Taxonomy for Teaching, Learning, and Assessment,' shifted from nouns to 'action verbs': Remember, Understand, Apply, Analyze, Evaluate, and Create. This taxonomy helps instructors design courses that meet qualified objectives. Regarding 'Experiential Learning,' the process moves beyond 'remembering' to 'applying,' as students must understand and perform tasks in diverse scenarios.

Roles of Feedback in Learning Environment

Feedback serves as information to bridge the gap between expected tasks and present performance (Nidup & Wangchuk, 2022). Hattie and Timperley (2007) defined it as a consequence of performance, provided by various agents. For instance, teachers provide corrective information, while peers or parents offer support and encouragement. Research indicates that students view feedback as a vital tool for skill acquisition and identifying strengths and weaknesses (Asnawi et al., 2017; Nidup & Wangchuk, 2022). In an active learning environment, 'peer feedback' enhances self-learning, teamwork, and critical thinking. Legette and Royo (2021) described it as a powerful tool that makes students feel supported while clarifying tasks. Furthermore, Dominique et al. (2002) noted that peer evaluation reduces reliance on teachers and stimulates independent learning.

Hattie and Timperley (2007) emphasized that peer feedback is particularly effective when the goal is improvement rather than grading. Wu and Miller (2020) added that it allows students to become 'producers of knowledge' by occupying both the provider and receiver roles. This dual role requires students to verify their own understanding before guiding others, thereby stimulating critical thinking (Legette & Royo, 2021).

A Teacher's Roles in Peer Feedback Learning Approach

In an experiential approach, Rogers viewed the teacher as a facilitator (Drummond, 2003). Rather than giving direct instructions, the teacher creates a pleasant environment that encourages self-learning. The teacher observes and assists when necessary, ensuring the environment does not hinder the learners' progress.

Related Studies on 'Peer Feedback'

Liu and Carless (2006) defined peer feedback as a dialogue-based communication process that enables students to manage their own learning. Their findings suggested that students learn not only from the feedback itself but also from reflecting on their own work. In Thailand, Kalong (2018) found that peer feedback led to more significant writing improvement than teacher feedback. Similar positive effects on writing were reported by Kusumaningrum et al. (2019) and Kunwongse (2013), who noted benefits such as increased confidence, active learning, and collaborative support.

However, Kunwongse (2013) also identified potential drawbacks: the approach can be time-consuming, and students may doubt the reliability of peer input. Cultural factors, such as 'saving face,' may also prevent students from providing sincere feedback. Additionally, teachers may feel uncomfortable regarding the quality and correctness of peer comments. Thus, applying the approach properly is essential for its success.

Research methodology

Participants

The participants in this study consisted of twenty-six pre-service teachers majoring in English at a public university in Northeastern Thailand. They were selected through purposive sampling (Creswell & Creswell, 2018), a non-probability sampling technique employed to ensure that the participants possessed the specific pedagogical knowledge and experience necessary to address the research objectives. Specifically, the participants comprised third-year students enrolled in an English presentation course where the APPLE Model was implemented. This particular group was selected because they were at a critical stage of developing professional communication skills and preparing for their future teaching careers. As novice teachers-to-be, their mastery of dual-role feedback, acting as both provider and receiver, is considered an essential competency for classroom effectiveness. Thus, they represent a highly suitable group for illuminating the perceptions of the structured peer feedback process. In the context of teacher education, this feedback process serves as a form of 'reflective practice.' By providing feedback to their peers, pre-service teachers develop the analytical skills necessary for their future professional role, while receiving feedback helps them refine their communicative competence and pedagogical awareness.

Research Instruments

To ensure a comprehensive understanding of the feedback process, this study employed a mixed-methods instrumentation approach. The primary tool was a 5-point Likert scale questionnaire, which was developed based on Rogers' Feedback Theory (1961, 1970) to capture a nuanced spectrum of peer evaluative responses. To ensure content validity, the instrument was validated by a panel of three experts in the field of English Language Teaching (ELT).

In addition to the questionnaire, two qualitative instruments were utilized for data triangulation: (1) a Classroom Observation Sheet, used by the instructor to record actual feedback behaviors and student interactions, and (2) a digital Feedback Provider Form, designed to capture the specific types of comments given by students. These qualitative sources provided deeper insights into the five categories of feedback adapted from Rogers: Evaluative, Interpretive, Supportive, Probing, and Understanding feedback. By moving beyond the simple separation of positive and negative feedback, these instruments allowed for a more sophisticated analysis of student perceptions.

Procedures

The study implemented a five-stage framework titled APPLE (Acknowledging: Practicing: Performing: Laying Feedback: Evaluating Feedback). This model extends the traditional PPP approach by integrating structured feedback stages rooted in Kolb's Experiential Learning Theory and Rogers' Feedback Theory. The model acts as a pedagogical scaffold designed to lessen psychological barriers common among novice teachers. The stages are as follows:

- Acknowledging: Corresponds to Kolb's Abstract Conceptualization, focusing on the foundational principles of effective presentation.
- Practicing: Aligns with Rogers' emphasis on reducing psychological threats. The instructor acts as a coach to facilitate initial peer suggestions.
- Performing: Students deliver their official presentations to the class.
- Laying Feedback: Applying Rogers' supportive categories, audiences provide anonymous feedback via the digital form. This anonymity is crucial in the Thai educational context to reduce anxiety and social friction.
- Evaluating Feedback: Presenters review and evaluate the utility of the received comments for future improvement.

Distinct from general peer feedback, the APPLE Model serves as a scaffolded framework designed to address the psychological barriers of novice teachers. The questionnaire and observation data were analyzed to explore students' perceptions of their dual roles and to identify the most beneficial types of feedback for their future teaching practices.

Data Analysis

Quantitative data from the Likert-scale items were analyzed using descriptive statistics, specifically Mean ($\bar{x}$) and Standard Deviation (S.D.), to identify general patterns in dual-role perceptions. Simultaneously, qualitative data from the open-ended questions, observation sheets, and feedback forms were analyzed through thematic analysis (Braun & Clarke, 2006). This involved a systematic process of coding and categorizing responses into themes to complement the numerical findings and provide a holistic view of the pre-service teachers' experiences.

Findings

Perceptions of Being a Feedback Provider

Participants rated their level of agreement regarding their role as feedback providers across five key dimensions. Data were analyzed using Mean ($\bar{X}$) and Standard Deviation (S.D.), as shown in Table 1.

Table 1 Perceptions of Being a Feedback Provider

Statements	Mean	S.D.	Interpretation
1. Comprehension of the provided feedback	4.23	0.81	High
2. Confidence of being a feedback provider	3.42	0.85	Moderate
3. Expectation of Application	3.65	0.93	High
4. Usefulness of the provided feedback	4.15	0.73	High
5. Self-awareness of the provided feedback	4.15	0.73	High
Total Average	3.92	0.50	High

As illustrated in Table 1, the participants demonstrated a high level of perception toward being feedback providers, with an overall mean score of 3.92 (S.D. = 0.50). The items with the highest mean scores were comprehension of the feedback provided ($\bar{x}$ = 4.23, S.D. = 0.81), followed by self-awareness of the feedback provided ($\bar{x}$ = 4.15, S.D. = 0.73) and the usefulness of the feedback provided ($\bar{x}$ = 4.15, S.D. = 0.73). On the other hand, the confidence of being a feedback provider recorded the lowest mean score within this category ($\bar{x}$ = 3.42, S.D. = 0.85), which is interpreted as a moderate level. These findings suggest that while the pre-service teachers felt highly conscious and capable in their role as providers, their confidence in giving feedback was slightly lower, reflecting a more cautious self-evaluation of their expertise.

Perceptions of Being a Feedback Receiver

Participants also rated their perceptions of being feedback receivers. The results are summarized in Table 2.

Table 2 Perceptions of Being a Feedback Receiver

Statements	Mean	S.D.	Interpretation
1. The reliability of the received feedback	3.95	0.60	High
2. Usefulness of the received feedback	4.25	0.91	High
3. Possibility of Application	4.40	0.75	High
4. The influence of the received feedback	4.50	0.61	High
5. Satisfaction of the received feedback	4.25	0.64	High
Total Average	4.27	0.70	High

Table 2 presents the participants' perceptions of their role as feedback receivers. The overall mean score was 4.27 (S.D. = 0.70), indicating a high level of positive perception toward receiving peer feedback. The highest mean score was recorded for the influence of the feedback received ($\bar{x}$ = 4.50, S.D. = 0.61), which demonstrates that participants strongly believed peer comments significantly impacted their learning and performance. This was followed by the possibility of application ($\bar{x}$ = 4.40, S.D. = 0.75), suggesting a high readiness to implement suggestions in future tasks. While all items were interpreted at a high level, the reliability of the feedback received recorded the lowest mean score in this category ($\bar{x}$ = 3.95, S.D. = 0.60). This indicates that although participants valued the feedback, they maintained a slightly more critical stance regarding its accuracy compared to other aspects.

The Favorable Type of Feedback

The participants' opinions toward their preferable feedback types were shown as follows;

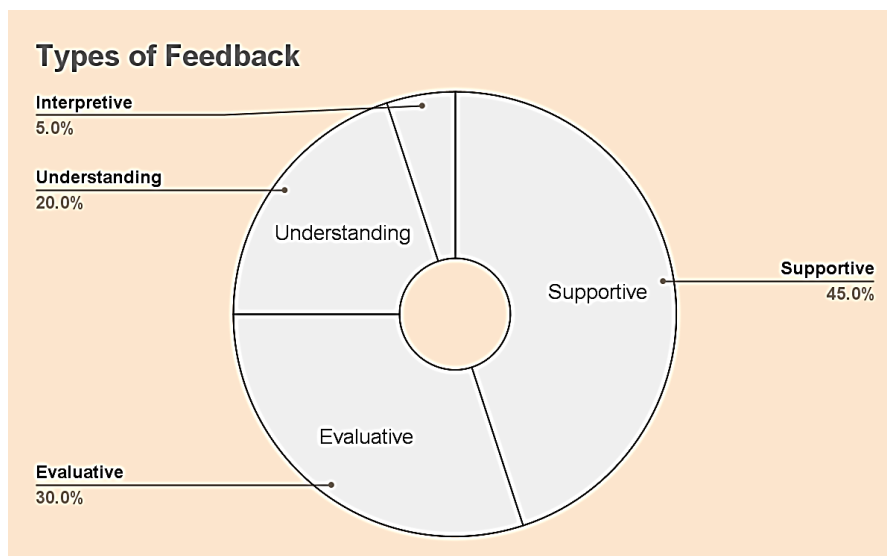


Figure 1 The Favorable Type of Feedback

As shown in Figure 1, qualitative insights from the open-ended section suggested that students preferred 'Supportive Feedback' because it acted as a 'morale booster.' One student noted that receiving positive reinforcement alongside corrections made them feel less intimidated by the English presentation process.

To elaborate, participants' preferences for specific feedback types are illustrated in Figure 1. The results revealed that 45% of participants preferred 'Supportive Feedback' (encouraging comments to boost performance). This was followed by 'Evaluative Feedback' (30%), which involves assessing the

performance of a target skill, and 'Understanding Feedback' (20%), characterized by empathy and compromise. Notably, none of the participants selected 'Probing Feedback' (critical questioning). This may be attributed to the written format of the feedback sessions, which provided limited space for the interactive, critical questioning typically required for probing feedback.

The quantitative results regarding feedback preferences revealed that Supportive Feedback was the most favored category (45%). This preference was strongly mirrored in the participants' qualitative reflections. Students noted that while they valued honesty, the emotional tone of the feedback was crucial for their learning mindset. As one participant described, the peer comments were described as being 'honest and direct, yet still soft for the heart', allowing them to acknowledge flaws without losing motivation.

Furthermore, the findings indicated that the APPLE Model provided a sense of security and authenticity. One student highlighted that the structured process allowed them to receive 'diverse perspectives, reflecting the real-world reactions they would encounter in public speaking situations.' This suggests that the model successfully bridged the gap between classroom practice and professional reality. However, the dual-role process also introduced psychological challenges. Despite the high favorability of the model, some students reported feeling internal pressure. One participant honestly reflected that while the feedback pointed out overlooked elements, 'some comments also induced significant pressure upon reading.' Another student described the experience as 'High Risk, High Reward,' emphasizing that the success of this peer-led approach heavily depends on the students' courage to be both vulnerable as receivers and courageous as providers of honest insights.

Participants' Overall Opinions toward the Peer Feedback Approach

The open-ended responses explored participants' opinions on the 'peer feedback learning approach.' Most participants expressed satisfaction, showing appreciation for the insights gained from their peers. However, some students raised concerns regarding the practical application of this approach, which will be further discussed in the next section.

Discussion

The Role of Being a Feedback Provider

The questionnaire explored whether feedback providers felt knowledgeable enough to provide feedback. Interestingly, only 5% rated their comprehension at the highest level (Level 5). Open-ended questions revealed that participants were concerned about being overconfident, as they still identified some mistakes in their own presentations. For these pre-service teachers, a 'Level 5' rating implied perfection, which they felt they had not yet achieved. Consequently, the majority (45%) rated themselves at Level 4 (Agree) or Level 3 (Neutral), suggesting that while they felt qualified to provide feedback, they remained aware of their own need for improvement.

This self-skepticism was reflected in one participant's qualitative reflection, describing the process as 'High Risk, High Reward.' The student noted that the success of the model heavily depends on whether the provider can give truly useful information; otherwise, it might not sufficiently promote learning. This highlights that while they felt qualified, they also felt a pedagogical responsibility toward their peers.

Despite this awareness, 95% of participants scored between 3 and 5 regarding their readiness to be feedback providers, correlating with their reported confidence levels. Classroom observations confirmed this, as most participants engaged attentively in the feedback process. Regarding expectations, most providers believed their feedback would be beneficial. However, a small minority (5%) expressed doubt (Level 1), reflecting a concern where peer feedback is undervalued compared to traditional teacher-centered feedback. This reluctance to trust peer suggestions is common in contexts where teachers have traditionally played the crucial role.

Regarding the usefulness of the feedback they gave to other participants, the participants were rather confident that they were knowledgeable and qualified enough to be 'feedback providers'. As a result, most of them agreed that the feedback provided was useful for the receivers. This led to the last issue: their self-awareness of being 'feedback providers'. Since they could provide feedback for others, they were expected to be aware of those given feedback. They were expected to perform better than those who got feedback from them. Moreover, when it was their turn to do a presentation, they were supposed to avoid committing similar mistakes they commented to their peers. The result showed that 35% of the participants confidently gave themselves 5. This could be evidence that they were aware of the feedback they gave to their peers.

Moreover, the role of feedback provider works properly as a teaching experience simulation for these participants as pre-service teachers. By evaluating their peers, they are practicing the skill of instructional supervision. The analytical process of identifying strengths and weaknesses in others enhances them to comprehend the assessment criteria, which they will later apply when grading and providing feedback to their own students. This 'learning by doing' approach within the APPLE Model thus bridges the gap between theoretical pedagogical knowledge and practical classroom application.

The Role of Being a Feedback Receiver

Participants highly valued the feedback they received, with most rating reliability at Level 4 or 5. This aligns with Asnawi et al. (2017), who found that feedback is only effective when receivers perceive its significance. The high reliability scores suggest that participants were aware of their own weaknesses and agreed with their peers' observations.

The quality of feedback was a key factor in its perceived usefulness. Participants noted that peers provided practical suggestions beyond simple 'good' or 'bad' comments. The strong correlation between usefulness, possibility of application, and influence ($\bar{X}=4.50$) indicates that participants were ready to apply peer suggestions into future performances. This process; performing, receiving feedback, reflecting, and applying directly fit with Kolb's Experiential Learning Cycle, demonstrating that the APPLE Model effectively enhances experiential learning. The value of this experience was reflected by students who expressed that the APPLE Model allowed them to receive 'diverse perspectives, reflecting real-world reactions they would encounter in public speaking situations.' This demonstrates that the participants did not merely see peer feedback as a classroom exercise, but as a gateway to professional authenticity.

In addition, the findings revealed a higher mean score for the role of feedback receiver ($\bar{x}=4.27$) compared to the feedback provider ($\bar{x}=3.92$). This statistic suggests that while pre-service teachers highly value the impact of receiving peer feedback on their performance (as seen in the highest score of $\bar{x}=4.50$ for influence), they still experience hesitation and difficulty when performing as feedback providers. This aligns with the 'reluctance' revealed by some participants who viewed themselves as novices. This phenomenon can be explained through Carl Rogers' theory, where the perceived threat of lacking expertise obstructs the evaluative process; therefore, a supportive environment is required to boost the feedback provider's confidence.

The Favorable Type of Feedback

The third section of the questionnaire was devoted to exploring the favorable types of feedback which the participants considered useful and beneficial for them. The result revealed that the most favorable type of feedback preferred by the participants was 'Supportive Feedback' which refers to the feedback that provides supportive phrases or comments that encourage the participants to do a better performance. The majority of the participants preferred this kind of feedback to others since they considered it was 'receiver friendly'. The preference for Supportive Feedback (45%) reflects the cultural context of Thai pre-service teachers. According to Kolb's theory, learners in the 'Concrete Experience' stage seek encouragement to maintain motivation. Supportive comments provide the emotional and professional scaffolding necessary for novice teachers during the APPLE process. While participants acknowledged their mistakes, they preferred positive reinforcement over negative criticism, which Asnawi et al. (2017) noted can stimulate better future performance. This preference for a balance between honesty and empathy was captured by a participant who appreciated feedback

that was 'honest and direct, yet still soft for the heart.' This qualitative insight explains why Supportive Feedback (45%) was dominant; it allows for growth without compromising the novice teacher's emotional well-being.

The high level of interest in Supportive Feedback, can be very significant for future jobs as novice teachers. The desire for Supportive Feedback shows that the participants have learned how important it is in the Thai context to provide a supportive environment to reduce student anxiety. As future educators, their firsthand experience with the APPLE Model teaches them that 'correcting' their students is only a part of teaching; helping their students improve over time is what is most beneficial. It is assumed that these novice teachers will develop their own instructional styles that are less structured and more focused on developing their students' potential with a supportive approach that aligns with 21st-century student-centered learning.

The students' second choice was Evaluative Feedback; these students wanted clear, concise evaluations of their work that would clearly state the positive or negative aspects of their performance, free of vague comments. The lack of response for Probing Feedback (0%), likely results from the written format of this survey which does not lend itself to real-time, oral probing.

Opinions of the Participants toward 'Peer Feedback Learning Approach'

The question in the last part of the questionnaire was 'What is your opinion towards participating in the 'peer feedback learning approach'?' Participants expressed two main themes: appreciation and concern.

Appreciation: All participants expressed appreciation for receiving peer feedback, stating it served as a beneficial guideline for improving their presentation skills. This is consistent with the findings of Nidup and Wangchuk (2022), which revealed that participants found peer feedback useful for providing clear guidance on performance enhancement. Participants further noted that without peer feedback, identifying their own weaknesses or mistakes would have been difficult. Interestingly, the process of providing feedback also raised their own learning awareness; by paying closer attention to their friends' performances to offer constructive comments, they simultaneously improved their own presentation preparation. This finding is supported by Wu and Miller (2022), who suggested that peer feedback promotes students to become 'producers of knowledge,' reducing sole reliance on teachers as they learn through the dual roles of provider and receiver.

Furthermore, participants reported high satisfaction with the peer feedback approach, reaffirming Legette and Royo (2021), who identified it as a valuable classroom technique. Beyond being active participants rather than passive listeners, students admitted the approach helped them become 'better thinkers.' Providing feedback required them to practice critical thinking by attentively analyzing their peers' strengths and weaknesses. Writing sufficient, reasoned comments also trained them to be more reflective. This indicates that participants did not only observe others but also engaged in self-observation. Therefore, the 'learning by doing' aspect of peer feedback significantly contributed to the development of the participants' thinking and analytical skills.

Concern: Although participants appreciated the feedback, some expressed concerns regarding the process. The questionnaire revealed that some participants felt slightly discouraged after reading certain comments. They explained that this feeling was caused by straightforward feedback that made them feel uncomfortable. Nevertheless, this emotional response occurred primarily during their initial reading. Subsequently, they were able to extract useful suggestions and adapt them for their upcoming presentations. This phenomenon suggests that providing feedback in written form may offer more space for the provider to be direct. Because providers knew their comments were anonymous and would not be tracked, they used words that conveyed exact meanings without compromising. Consequently, these straightforward expressions occasionally triggered negative feelings in the receivers. Some students admitted that while the feedback was helpful, reading comments that pointed out overlooked flaws 'induced significant pressure' or even 'stress', particularly when the feedback was perceived as being delivered in front of others. This emotional weight reinforces the

need for the APPLE Model's structured stages to include emotional scaffolding to help students process direct criticism effectively.

In addition, while participants agreed with the peer feedback approach in principle, they raised concerns about the quality of the feedback provided by their peers. Although their classmates provided clarifications, participants worried about potential omissions of certain mistakes. Since their peers were also considered novices in providing feedback, participants feared they might not be able to identify every detail or might only point out obvious errors rather than crucial ones. For these participants, teacher confirmation was still required to ensure that the feedback received was both correct and sufficient. This concern is understandable, as Asnawi et al. (2017) stated that some students find teacher feedback to be a necessary component of their learning process.

Conclusion and Implications

In conclusion, this research offers a fresh perspective by illustrating that the efficacy of peer feedback is not solely dependent on the quality of comments, but also on the structured role-switching of participants within the APPLE Model. The results suggest that participants felt generally confident in their dual roles, with the model serving as a vital bridge between their initial hesitation and their developmental needs. Notably, participants expressed high satisfaction with 'Supportive Feedback', which they described as being 'honest yet soft for the heart.' This preference indicates that supportive comments provide not only necessary information for improvement but also the emotional encouragement required to sustain motivation within the Thai teacher-education context.

Building on these insights, this study offers crucial pedagogical implications for EFL teacher training. First, the APPLE Model provides a structured scaffold that reduces student anxiety, serving as a template for pre-service teachers to manage peer-learning in their future careers. Second, the results highlight the necessity of explicit training on various feedback types. Teacher education programs should prioritize the development of feedback proficiency, ensuring that novice teachers are not only linguistically competent but also pedagogically skilled in the art of constructive critique, effectively transitioning from being students to being professional facilitators of knowledge.

However, to provide a comprehensive view, certain research limitations must be acknowledged. The primary limitation is the relatively small sample size of twenty-six pre-service teachers from a single university context; consequently, the findings may not be fully generalizable to all institutions in Thailand. To address this, future research should involve a larger and more diverse group of participants to enhance generalizability. Furthermore, a longitudinal study tracking the long-term retention of these feedback skills or exploring the integration of Generative AI tools as a feedback scaffold, would offer valuable new insights into the evolution of peer review dynamics in the digital era.

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Enhancing TOEFL ITP Performance through the Development of an Innovative Web-Based Online Testing System

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ABSTRACT

Web technology offers abundant resources for educators and learners in the process of teaching and learning English. This research focuses on developing a web-based online test for the TOEFL ITP, tailored to the needs of learners and educators at Universitas Darussalam Gontor. The novelty of this study lies in the development of a comprehensive TOEFL ITP system that evaluates all three key skills: listening, structure and written expression, and reading, while also incorporating a scoring feature to evaluate learners' performance. To address the challenges of online test development, the study utilized the Instructional System Design (ISD) model developed by Alessi and Trollip (2001). The formative evaluation process involved assessing the system's impact through a pre-test and post-test comparison, with the primary goal of enhancing learners' TOEFL ITP performance and motivation. A paired-sample t-test was employed to analyze the improvement in learners' performance. Results revealed a mean score increase from 469.12 (pre-test) to 532.36 (post-test), a difference of 63.24. The t-statistics of -9.03 and p-value of < 0.01 confirmed that the improvement was statistically significant. Additionally, learners' motivation showed a gain score of 0.53, indicating a notable increase in motivation after engaging with the web-based test system. These results demonstrated that integrating web-based systems into TOEFL preparation has substantial benefits for learners' engagement, performance, and cognitive development. The study also highlights the potential of using such technology in providing more accessible and interactive learning experiences for learners in various educational settings.

Keywords: TOEFL ITP, Performance; WEB, Online Test

Introduction

Test of English as a Foreign Language Institutional Testing Program (TOEFL ITP) as an English proficiency test is used to assess non-native speakers' capacity to use and comprehend the language in educational contexts (Anam et al., 2017; Golubovich et al., 2018). It plays a crucial role in the academic world, particularly for individuals aiming to pursue studies at international universities or participate in English-language programs. The test comprehensively measures proficiency in listening, reading, structure and written expression that are essential for success in academic environments (Kalantar, 2023; Nirwaty, 2020). TOEFL ITP also serves as a benchmark for institutions to assess an individual's readiness to engage with coursework, understand academic materials, and communicate effectively in global classrooms. Mastering TOEFL not only supports academic aspirations but also strengthens global competitiveness (Sasayama et al., 2021)

Ukhrowi (2024) discusses the use of websites as platforms for TOEFL practice, providing reading and structure questions but excluding the listening component. The primary restrictions of this platform are the limited number of questions and the absence of the listening section, which is essential in a full TOEFL assessment. However, the web provides flexible access, enabling users to practice anytime and anywhere according to their needs. These studies by Aprilliandari and Sugiharto (2023) and Ukhrowi (2024) examine the use of websites for TOEFL practice, which offers a limited number of questions in the Listening, Reading, and Structure sections. Although the limited number of questions is a drawback, users can still access various types of practice conveniently. Additionally, the platform provides flexibility, allowing users to practice from anywhere and at any time, even though it lacks scoring features that could help assess their progress. Istighfaroh et al. (2023) study ELT learners'

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awareness and attitudes regarding the use of web-based online tests for English learning. The findings demonstrate that learners feel positively about these resources and grow more knowledgeable about the online resources utilized in the English language learning process. The online setting supports learners in independently evaluating their learning objectives and promotes self-regulated learning.

Based on the background outlined, there are scarcities in research related to the use of the web to evaluate the TOEFL ITP test, particularly concerning the quantity and types of questions that align with the standards set by Educational Testing Service (ETS). Previous studies have shown that TOEFL training has not met the number of questions recommended by ETS, resulting in an inadequate assessment of the test-takers' academic abilities (Kalantar, 2023; Sasayama et al., 2021). This issue highlights the need to develop a web-based platform that can provide a more varied set of TOEFL ITP questions that meet ETS criteria. In addition to meeting ETS criteria, this application also includes a scoring feature, allowing users to view their scores after completing the test. Therefore, this research focuses on addressing this gap to ensure that the evaluation of English language proficiency in an academic context can be performed more accurately. One of the key significances of this study is the development of a web-based platform that lets learners access TOEFL practice materials anytime, anywhere, offering a more flexible and convenient approach to preparation. This feature is especially significant in the context of modern education, where learners are increasingly seeking independent, self-paced learning opportunities. By offering a platform aligning with ETS standards and including a scoring system for immediate feedback, this research contributes to enhancing learners' English proficiency outside of traditional classroom settings, assisting them in better preparing for academic challenges. The research aimed to address this problem by creating an application that satisfies TOEFL proficiency test requirements and assessing learners in maximizing their academic proficiency. It sought to explore the following research questions:

1. How can a web-based online testing system be facilitated for the TOEFL ITP?
2. To what extent are the learners' learning motivation and learning outcome after implementing TOEFL ITP online test?

Literature review

TOEFL ITP and Performance Factor

TOEFL ITP is designed to assess English language proficiency through three core components (Apriliandari & Sugiharto, 2023; Ariamanesh et al., 2023; Ukhrow, 2024). Understanding spoken English is assessed in the listening comprehension section in academic settings, such as classroom discussions and conversations, requiring test-takers to grasp both main ideas and details. The structure and written expression section evaluates mastery of English grammar and the ability to recognize correct sentence structures and avoid errors in written academic language, a skill crucial for producing clear, professional writing (Istighfaroh et al., 2023). Meanwhile, the ability to read and comprehend challenging academic texts, analyze content, make deductions, and recognize key ideas is assessed in the reading comprehension section (Fleckenstein et al., 2020; Sadeghi et al., 2021). Although TOEFL ITP does not include speaking or writing sections, it provides a reliable assessment of essential skills for non-native speakers who need to navigate the demands of academic reading and listening. This makes it particularly useful for institutions that need a standardized test to evaluate English proficiency in an academic setting.

Practice questions and exam simulations have a crucial role in enhancing TOEFL ITP performance by helping learners effectively prepare through familiarity with the test format and by optimizing the language skills assessed. Practice questions include a range of TOEFL ITP questions which aim at training participants on question patterns and enhance answer accuracy. Varied question types, such as multiple-choice, error identification, and reading comprehension, provide opportunities for participants to identify weaknesses and refine answering strategies. Meanwhile, exam simulations serve as a realistic test experience, including time constraints and question formats similar to the actual test, allowing test-takers to acclimate to the time pressure and real test conditions (Ariamanesh et al., 2023). Through consistent practice, the participants are able to develop resilience, confidence, and better time management, all of which contribute to enhanced performance on the TOEFL ITP.

In the context of this study, Daniels (2016) provides a valuable framework for understanding how learners interact with and internalize the content of the TOEFL ITP test. Daniels (2016) argues that learning occurs through social interaction and mentorship, particularly within the Zone of Proximal Development. The web-based TOEFL test functions as a tool for scaffolding learners' progress, offering organized support through feedback that helps learners from their current abilities to more advanced proficiency. The formative assessment model proposed by Xuan and Wishart (2022) highlights that assessment should go beyond merely evaluating performance; it should actively contribute to the learning process. The web-based TOEFL ITP test embodies this principle by offering real-time feedback that helps learners understand their strengths and weaknesses. According to Xuan and Wishart (2022), formative assessments enable learners to identify areas for improvement, guide instructional decisions, and ultimately enhance learning outcomes. The ongoing feedback offered by the web-based system reflects this model, as it empowers learners to monitor their progress and adjust their strategies, accordingly, promoting a more engaging and learner-centered approach to TOEFL preparation.

The study employs Self-Determination Theory (SDT) by Yuerong et al. (2024), which posits that motivation is shaped by three key factors: autonomy, competence, and relatedness. The web-based TOEFL ITP test supports autonomy by allowing learners to learn at their own pace within a flexible setting. It fosters competence by providing immediate feedback, enabling learners to track their progress and refine their skills. Furthermore, the engaging and interactive nature of the test fosters relatedness, as learners feel more connected to their learning goals through supportive online platform. Incorporating SDT highlights, this study demonstrates how the web-based test can not only boost learners' performance but also increase their intrinsic motivation by fulfilling their psychological needs for autonomy, competence, and relatedness.

Web-based online testing system

A website is a collection of interconnected digital pages accessible via the internet, serving as a medium to present information, services, or interactive applications to users (Aljraiwi, 2019). Websites are essential for supporting online tests like TOEFL as they provide an accessible, efficient, and well-structured platform for test-takers (Iyamuremye et al., 2024). With features such as automatic registration systems, exam scheduling, and integration with proctoring software, websites ensure the security and accuracy of the test administration. Additionally, their wide accessibility allows participants from various locations to take the test without physical presence, saving time and costs (Alsuhaibani et al., 2024; Aydos et al., 2022). Websites can also store test results and offer immediate feedback, which greatly assists in the evaluation process (Chandra & Qomariyah, 2022; Hsu, 2024).

The use of web-based online testing systems in education has offered significant advantages in improving learner performance, reducing exam-related anxiety, and facilitating faster feedback. These systems let learners take exams remotely and at flexible times, improving accessibility and creating a more comfortable testing environment. Study indicates that online testing positively impacts learners' performance by providing adaptive question formats and instant feedback, enabling learners to identify areas for enhancement promptly (Ariamanesh et al., 2023). Additionally, the immediate scoring and automated feedback reduce delays in learning adjustments, getting educators to tailor their instruction more effectively to individual learners' needs (Aljraiwi, 2019). Lowering the stress often associated with traditional exams through a more familiar digital interface, online testing systems create an environment that supports both academic performance and learners' well-being.

Challenges in Thai EFL Writing Instruction

Thai EFL students face significant difficulties in idea generation, argument organization, and the use of cohesive devices (Wonglekha & Khamkhien, 2022). Traditional instruction often prioritizes grammar drills and memorization over meaningful writing practice, limiting exposure to well-structured academic texts. Additionally, exam-oriented teaching reduces opportunities for process-based writing tasks. These constraints suggest a need for strategies that increase both exposure to and awareness of essential writing structures without drastically altering existing curricula (Laksanasut, 2024).

Input Flooding: Enhancing Fluency and Accuracy

Input flooding involves repeated exposure to specific linguistic forms to promote acquisition. Studies indicate that sustained exposure to transitional phrases and complex structures improves EFL students' fluency and accuracy in writing (Alwaheebi, 2024). For Thai learners, who typically lack rich linguistic input, this approach may provide the necessary scaffolding to internalize advanced structures. However, some research suggests that input flooding alone may be insufficient, particularly for students who require explicit attention-directing mechanisms to fully process new forms (Salih, 2023).

Input Enhancement: Promoting Conscious Noticing

Input enhancement supplements input flooding by highlighting key linguistic features using boldface, underlining, or other visual cues (Susoy & Zarfsaz, 2024). Aligned with Schmidt's Noticing Hypothesis, this technique helps students recognize and adopt complex syntax, cohesive devices, and grammatical structures essential for clear and coherent writing. Empirical studies have shown that enhanced input increases the likelihood of retention and application of target forms in student essays (Salih, 2023).

Research methodology

This research developed an online test for TOEFL ITP section, created using react.js for the front-end and node.js for the back end. The development process followed a research and development model based on the framework proposed by (Alessi & Trollip, 2001). This model incorporated three essential attributes of Instructional System Design (ISD): standards, evaluation, and project management, which were central to the design and development process, establishing a solid foundation (Alessi & Trollip, 2001). By clarifying the standards, the design development was closely monitored to meet benchmarks. Furthermore, continuous evaluation was conducted at each stage, utilizing a continual iterative approach until the desired functionalities were achieved. The process of development was adaptable, with each step contingent upon the outcomes of the previous one. Additionally, project management was a significant focus within the Alessi and Trollip (2001) ISD model, ensuring the online test was completed within the set timeframe and budget. Any delays were addressed while maintaining standards (Nugroho & Arrosyad, 2020). Figure 1 below illustrates the Alessi and Trollip (2001) model.

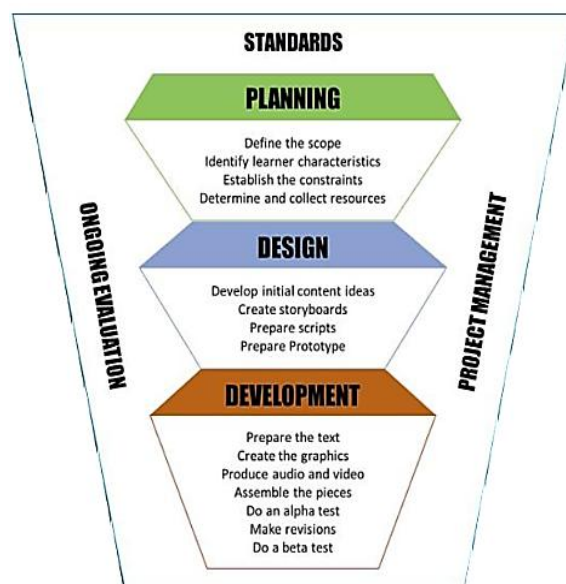


Figure 1 The Design Model for the Alessi and Trollip Instructional System

A web-based online testing system for the TOEFL ITP test was created using the three stages of Alessi and Trollip (2001)'s Instructional System Design (ISD): planning, design, and development. The planning phase aimed to ensure that all system aspects functioned effectively, encompassing defining the study's scope, identifying learner characteristics, establishing the boundaries of the web-based test, determining the format of the instructional manual, and conducting initial brainstorming sessions (Hakim et al., 2021). The design phase was the most creative, focusing on content assembly and deciding how to create an interactive and instructional online test system that supports learners in achieving their learning outcomes (Nurrahmi & Putri, 2024). During this stage, task and concept analyses were carried out, and storyboards and flowcharts for the online test were created. Converting the design into a web-based online system for the TOEFL ITP test was the last stage. The process of development involved teamwork and required the creation of reading materials and supplementary materials in addition to a variety of programming and graphic design abilities.

Product testing was divided into two categories when creating the web-based online testing system for the TOEFL exam: determining the system's viability and analyzing its efficacy. Alpha testing (validation by media and material experts) and beta testing (learner assessments) were both included in the feasibility testing process. The information gathered from these assessments was examined to enhance the final product, making sure that the media produced better matched the requirements of the learners. Summative tests were used to gauge the product's efficacy and ascertain whether learners' scores, motivation, and general accomplishment improved after the developed product was put into use.

The ISD model by Alessi and Trollip (2001) was particularly suitable for the development of a TOEFL online testing system due to its structured approach to planning, design, and development. The model facilitated a clear alignment between educational goals and the necessary system features. Its flexibility allowed adaptations during each phase based on feedback and evaluation results, making it well-suited for creating an interactive TOEFL ITP system. Additionally, the focus on standards and continuous evaluation ensured that the final product adhered to educational standards while supporting learners' cognitive development at the formal operational stage.

Participants

The summative assessment involved 65 male learners in their second semester from the International Relations major at Universitas Darussalam Gontor, Indonesia. All participants were chosen based on their academic performance. It is noteworthy that all the respondents were male, for the sampling was drawn from the university's campus A, where only male learners are enrolled. The university operates a pesantren (Islamic boarding school) system, where male and female learners are separated across different campuses. Female learners attend campus C, while campus A is designed for male learners. The participants represented a wide range of socio-economic backgrounds, with some hailing from urban areas and others from rural regions. Their English proficiency levels varied, with some learners having higher proficiency due to previous exposure to English-language programs, while others had more limited abilities. This demographic diversity contributed to a thorough evaluation and improved the generalizability of the results.

Instrument

Creating a high-quality development product requires the use of several well-defined instruments to evaluate various aspects of the research process. These instruments involved: (1) the primary instrument, which was a questionnaire designed to examine the quality of the web-based learning system. The questionnaire targeted two primary components: the content and the media, both of which were validated by subject matter experts. Additionally, the TOEFL ITP scores were used to measure enhancements in learners' cognitive performances by comparing pre-test and post-test results. This allowed for a direct evaluation of learners' progress; (2) supporting instruments, which included observation sheets to collect data on learners' characteristics, ensuring the accuracy of the design and the product. Additionally, interviews with product developers were held to obtain further insights, including feedback, suggestions, and critiques that were not captured by questionnaire.

Data Collection

The current study gathered several types of data including learners' opinions about the multimedia products, questionnaires about the created web platform, and validation results from media and content specialists. Together with information on learners' motivation and their pre- and post-test scores that reflected learning outcomes, these responses were transformed into a five-point scale

Data Analysis

Aspects of instructional quality (like instructional flexibility, testing, and assessment quality) as well as the quality of content and objectives (like accuracy, completeness, relevance, and suitability for the user's context) were among the criteria used to assess the web-based online TOEFL ITP test's quality. The web-based online test's evaluation criteria, which were adapted from Alessi and Trollip (2001), were centered on technical quality (which covered data storage and privacy, accessibility and stability, media compatibility, non-web contact information and program limitations) and display quality (which included text, colors, images/graphics, screen design, and navigation). Additionally, media attractiveness which included text, images, colors, materials and tests, screen design, user interface, communication features, and language was the main focus of assessing learners' impression of the web multimedia.

Since the experts offered recommendations and input on the created web-based online test, the formative evaluation's feedback from questionnaires and in-person interviews with media and material experts was compiled in a table without being transformed into quantitative data. In contrast, the summative assessment entailed comparing the data from pre-test and post-test to ascertain whether the outcomes of learning had improved, and evaluating questionnaire of learning motivation with a numerical scale based on a Likert scale. N-gain, which represents the normalized average score gain (g), was used to compute the improvement in learning outcomes prior to and following the adoption of the web-based online TOEFL ITP test. The gain score was calculated by comparing pre-test and post-test results; the highest gain score indicated the greatest possible improvement. Hake (1999) states that the following is the expression for the normalized average gain (N-gain). The result of N-Gain average calculation was interpreted using this criterion in Table 1.

$$g = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}}$$

Table 1 Division of Gain Score

Score	Category
N-Gain < 0,3	Low
0.3 N-Gain ≤ 0,7	Medium
N-Gain ≥ 0.7	High

In addition to the N-gain, the paired t-test was employed to analyze the difference between pre-test and post-test scores. This statistical test calculated the mean difference between the paired scores (post-test minus pre-test scores) and divided it by the standard deviation of the differences, adjusted by the square root of the sample size (McMillan & Schumacher, 2010). The result of the t-test determined if the difference in scores was statistically significant, providing insight into whether the web-based TOEFL ITP test led to meaningful improvements in learners' performance. t-value indicated that the observed improvement was unlikely to be due to random chance. The test results contributed to a deeper understanding of how the system helped learners' academic skills over time.

Results

How can a web-based online testing system be facilitated for the TOEFL ITP?

1. Planning Define the scope

The TOEFL ITP test was utilized in the present study. This test consisted of two main sections: practice 1 and practice 2. Each section was composed of Listening Comprehension (50 questions, 35 minutes), which tests understanding of conversations and lectures; Structure and Written Expression (40

questions, 25 minutes), which measures the skill to identify appropriate grammatical structures; and Reading Comprehension (50 questions, 55 minutes), which assesses the ability to understand academic texts. These two materials served as the core foundation for building conceptual understanding TOEFL ITP test.

2. Identify Learner Characteristics

At the formal operational stage, learners exhibited more logical and systematic thinking, which allowed them to be more self-reliant in learning. They utilized modern resources such as the internet, notebooks, and smartphones to stay informed and organize material. Capable of abstract thinking and complex problem-solving, they were well-equipped to face advanced academic challenges. This stage also involved increased self-regulation, critical thinking, and goal setting. Based on these characteristics, this study created a web-based TOEFL ITP test to support their cognitive abilities and encourage independent learning.

3. Establish the Constraints

When developing the web-based TOEFL ITP testing system, various constraints were addressed to ensure the system with educational goals. Technological factors such as device compatibility, internet bandwidth, and server capacity were considered to ensure accessibility across platforms. The system was also required to meet TOEFL ITP standards set by ETS, ensuring the correct types and numbers of questions for accurate assessment. User experience was a key constraint, demanding intuitive design that catered to learners' cognitive abilities at the formal operational stage, promoting independent learning. Furthermore, time and budget constraints guided the development process, requiring efficient resource management. Lastly, the system had to comply with accessibility guidelines, ensuring inclusivity for all learners.

4. Produce a Style Manual

(1) The homepage, test page, course page, information page, log-in page, and forum page were the six primary menus that made up the website layout. To make the learning environment more engaging, the test-page design was altered for every question level. (2) Courier New and Pristine fonts were used in the text; the material text was 12 points in size, while the homepage text and material titles were 16 points. (3) The website theme eschewed the use of bold icons or characters in favor of a minimalist template with a modern, futuristic design. (4) White and light blue were the template's primary colors. (5) Users only had to enter their username to access the user-friendly web-based test. (6) Keeping with the modern and futuristic theme, the navigation buttons were made to be aesthetically pleasing.

5. Design Conduct Task and Concept Analysis

The online version of TOEFL ITP test was designed to enhance English proficiency. It served as an interactive test platform that users could access anywhere for self-directed learning. The web utilized Macromedia Flash to create engaging animations and a visually appealing interface. This test promoted independent learning and shifted the focus from teacher-centered to learner-centered learning, helping learners improve their performance and achieve mastery. The passages of TOEFL ITP were designed with attention to word size, sentence length, and linguistic features to support comprehension. The available task types on the web-based TOEFL ITP test included listening, reading, structure and written expression.

6. Create Flowcharts and Storyboards

The basic flow or order of operations within the multimedia web system when accessed by users was depicted in flowcharts for the web-based test. After flowcharts were created, a storyboard was made to show the web product's initial visual design. Included in this were the test pages, material display, logo, main menu, and other features. The following flowchart illustrates how to use the web-based test according to the specified procedure.



Figure 2 The Procedure for Accessing TOEFL ITP Online Test

7. Development

The web-based online test for TOEFL ITP was developed using PHP programming and supported by a variety of tools, including Adobe Flash CS3, Notepad++, Corel Draw X4, Adobe Photoshop CS3, and Adobe Illustrator. Development began by preparing the materials and designing the interface, including menu content. Next, the programmers initiated the coding process following the established storyboards and flowcharts. Role-Based Access Control (RBAC) was implemented to define user roles, which included web manager, lecturer, and learners. Once coding and integration of media components were complete, the server as well as the website domain was finalized at <https://engrtest.unida.gontor.ac.id/>. Below is the web page profile for TOEFL ITP online test.

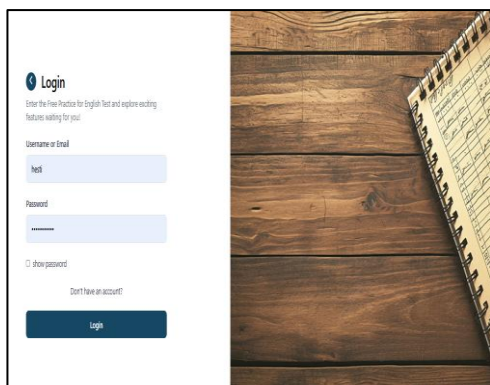


Figure 3 Register Form

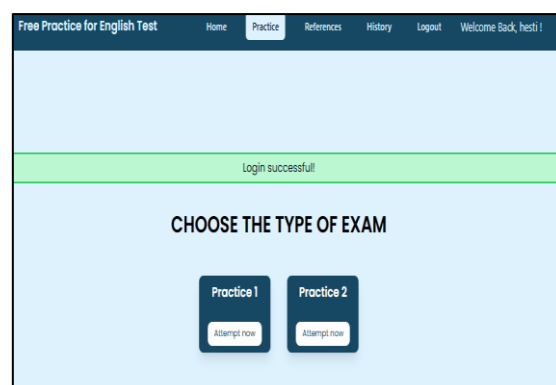


Figure 4 Test Platform

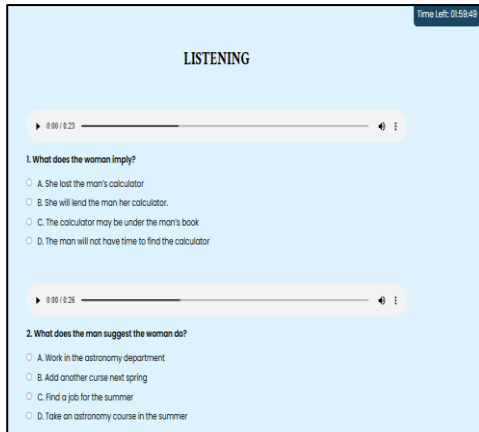


Figure 5 Listening Section

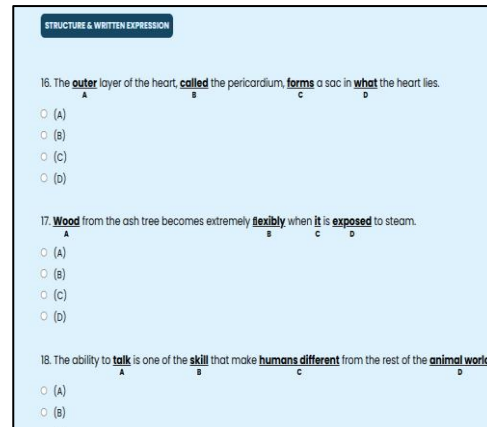


Figure 6 Structure & Written Expression

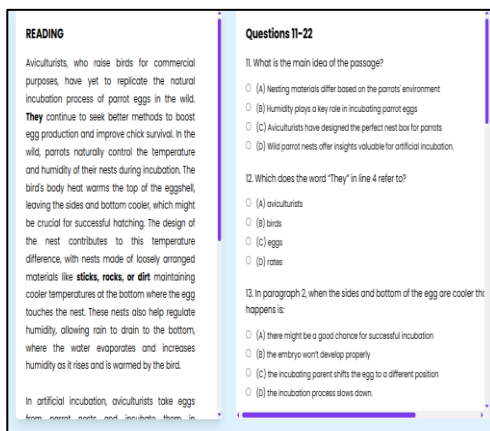


Figure 7 Reading Comprehension

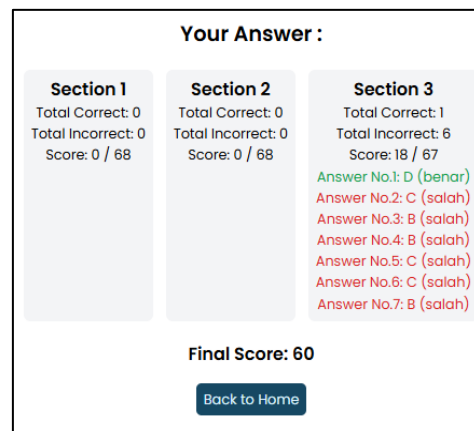


Figure 8 TOEFL ITP Score Figure

After the web-based TOEFL ITP test's multimedia learning was created, its viability was assessed before it was incorporated into the learning process. Alpha testing (product validation) and beta testing (user feedback) were the two testing phases that made up this formative assessment. Internal media specialists and TOEFL specialists were principally responsible for validation during alpha testing. While the media validation sought to assess the media programs' display and functionality, the material expert validation concentrated on determining whether the content was appropriate.

Subsequent examination of the validation results revealed that the web-based online TOEFL test coverage satisfied the exam's validity requirements. Media experts' comments verified that each component's corresponding indicators had been met. Nonetheless, it was evident from the media validation results that some media elements did not satisfy the required standards for accessibility and appearance. Although some improvements were required to produce a more practical multimedia product, the online test could still be used as part of the overall learning process. The web-based online test system was prepared for additional testing after these enhancements were made.

Table 2 The Assessment of Media Expert

No	Aspect	Score
1	System Management	4.38
2	User Interface	4.41
3	Educational Value	5.36

According to the media experts' feasibility assessment (Table 2), the online test's management component scored 4.38, which was considered "very good," and the user interface received a score of 4.41, which was also considered "very good." Media experts gave the web-based online test a 5.36 rating for its educational value. After reviewing each of the TOEFL ITP practice materials, the experts assessed the products based on two criteria: practicality and effectiveness. Practicality was reflected in the ease of accessing the TOEFL ITP practice test online and its applicability in the TOEFL class, while effectiveness was characterized by the usefulness of the materials for the TOEFL course. According to the feedback from the material experts, content validity in TOEFL ITP test scored above 4.21, indicating a "very good" category, alignment with TOEFL standards scored 4.13 categorized as "very good", and clarity and accuracy of language reached 4.28, also in the "very good" criteria. A questionnaire measuring media attractiveness served as the research tool for the beta test. Learners were requested to study and interact with every aspect of the online TOEFL ITP exam. Once the learning activity was considered adequate, learners took a test to evaluate their performance on the TOEFL ITP. Additionally, an impression questionnaire regarding the web multimedia was given to the learners, and the data obtained were analyzed using a Likert Scale (see Table 3).

Table 3 Result of Web Multimedia Impression

No	Aspect	Score
1	Combination of color	3.78
2	Presentation of Menu	4.30
3	Text Clarity	4.48
4	Web based instruction	4.28

Based on the feedback provided by the learners (Table 3), the website's color combinations received a score of 3.78 (good category), the menu presentation received a score of 4.30 (very good category), the text's clarity received an average score of 4.48 (very good category), and the website's usage instructions received a score of 4.28 (very good category). These findings demonstrated that the web-based online test successfully improved learning outcomes, with a gain score increase of 0.40 (medium-g courses).

To what extent are the learners' learning motivation and learning outcome after implementing the TOEFL ITP online test?

In this research, apart from gathering data from the pre-test and post-test, an additional focus was placed on assessing learners' motivation for the summative evaluation. This motivation assessment was conducted using an attitude questionnaire, which initially provided qualitative data. This data was transformed into quantitative form using a Likert scale in order to be further examined. Learners' motivation performance averaged 2.08 during the pre-test phase, but the average score rose to 3.62 during the post-test. The comparison between these two mean scores allowed the calculation of a gain score, revealing a significant difference in motivation levels before and after utilizing the online test. The main gain in motivation was found to be 0.53 (medium-g courses), indicating that learning motivation notably improved after the learners engaged with the TOEFL ITP web-based online test.

For further evaluation, a summative assessment was conducted through a classroom trial involving 65 learners, where they engaged with the web-based online test system. Prior to the trial, an offline TOEFL ITP pre-test was administered to assess the learners' initial cognitive abilities related to the TOEFL ITP test. The expectation was that 70% of the learners would achieve the passing grade of a TOEFL score of 500, indicating that the test materials were appropriate for the learners' level of proficiency. However, the results from the pre-test revealed that only 43% of learners managed to reach this target.

In contrast to the pre-test outcomes, where the average score was 469, the post-test results showed considerable improvement, with an average score of 532. Most learners passed the post-test, with seven learners considered incomplete. The enhancement in learning outcomes from the pre-test to the post-test led to a calculated gain score of 0.6, highlighting the effectiveness of the web-based online test in improving learners' performance in the TOEFL ITP. To further assess the significance of this improvement, a paired-sample t-test was performed. See Table 4 for the results of the paired-sample t-test.

Table 4 Paired-Sample t-Test Results

Statistic	Pre-test	Post-test	Difference
Sample Size (N)	65	65	65
Mean Score	469.12	532	63
t-Statistic	-9.03		
p-value	< 0.01		

Based on Table 4, the paired-sample t-test results revealed a mean score increase from 469.12 (pre-test) to 532.36 (post-test), indicating significant improvement in learners' performance after using the web-based online test system. The t-statistic was -9.03, showing a substantial difference between the pre-test and post-test scores. The p-value of < 0.01 was far below the typical significance level of 0.05, confirming that the observed improvement was statistically significant and not due to random chance. Overall, the study demonstrated that the web-based online test not only enhanced learners' motivation but also supported their cognitive development, reflected by the improved scores. These results suggested that integrating technology into TOEFL preparation offered substantial benefits for learners' engagement and performance.

The practical implications of these results are substantial. The web-based system provides learners with flexible access to practice materials, immediate feedback, and the ability to independently engage with content. These features promote learner autonomy and motivation, which are crucial for effective modern test preparation. This is especially important in contexts where learners may not have reliable access to traditional classroom-based resources or instructors. Beyond these general benefits, the system should be further improved by incorporating a wider range of test questions across various skill areas. The inclusion of three distinct types of questions: listening, reading, and structure would facilitate a comprehensive preparation experience. Listening exercises help improve learners' comprehension of spoken English, while reading exercises evaluate their comprehension of written materials. Structure-based questions would focus on grammar and sentence construction, ensuring comprehensive coverage of the skills necessary for the TOEFL ITP test.

Discussion

The findings from the web-based TOEFL ITP test study demonstrate its positive impact on learners' academic English proficiency, particularly in enhancing engagement, motivation, and performance outcomes. The user-centered design of the online test system emphasizing ease of navigation, intuitive layout, and clear menu labeling, has promoted independent learning. Positive feedback from both alpha and beta testing phases highlights that the system meets quality standards and is well-received by media and material experts, confirming its usability and validity in supporting TOEFL preparation. These results are consistent with previous research by Hidri and Pileh Roud (2020), revealing that intuitive interfaces significantly enhance learner engagement and performance. Additionally, the findings align with Simkova et al. (2021) and Arifuddin et al. (2023), who suggest that clear organization in online testing platform boosts learners' confidence and supports their performance outcomes.

The feasibility assessment and expert evaluations, which indicated strong content validity and high levels of clarity perceived by learners, demonstrate the system's short-term effectiveness. These results are consistent with previous studies on web-based assessment systems, which have reported that well-designed digital platforms can enhance learner engagement and immediate learning outcomes (Cattaneo et al., 2025; Chandra & Qomariyah, 2022). In addition, while the present study confirms the effectiveness of the web-based TOEFL ITP system in improving test performance, prior research suggests that benchmarking learning gains across different digital testing systems can offer a more comprehensive understanding of their relative effectiveness (Aydos et al., 2022; Boateng et al., 2024; Iyamuremye et al., 2024). Comparing the post-test score improvements observed in this study with findings from larger-scale or multi-institutional studies would help contextualize the results. Furthermore, examining whether the interactive features of the system produce sustained learning benefits across various educational settings, and how these features compare with those used in conventional TOEFL preparation methods, would provide valuable insights into the broader applicability and impact of the web-based TOEFL ITP test.

The web-based TOEFL ITP system yielded positive outcomes across all assessed skills. In listening comprehension, the system enhances learners' ability to understand academic spoken English, aligning with by Hidri and Pileh Roud (2020) and Zakharova et al. (2024) who find similar improvements with interactive listening tools. Reading comprehension also improves, suggesting that the system's academic texts and exercises have positive impact to learners' reading skills, consistent with Alsuhaibani et al. (2024). Structure-based questions also demonstrate improvements, indicating that the system provides valuable grammar practice, although further development in targeted writing strategies might be necessary. Overall, the system contributes to the development of learners' TOEFL skills, highlighting its potential boost performance across multiple areas.

The study emphasizes positive feedback and increased motivation, but it does not fully address potential limitations, such as technological constraints or device availability. Future research should assess the platform's effectiveness for learners from diverse socio-economic backgrounds, who may not have equal access to the necessary technology, as supported by (Sun & Wudthayagorn, 2024). Additionally, further investigation is needed to determine how well the system adapts to the specific needs of different learners, ensuring equitable access to all. Scalability is another crucial consideration; with a small sample size of 65 learners, future studies should examine the platform's effectiveness across larger, more varied populations. Investigating its potential for wider implementation across various educational settings and regions will be essential for broader adoption, particularly in developing countries where access to traditional TOEFL preparation resources may be limited. In line with research by Zakharova et al. (2024), a systematic exploration of the long-term benefits of technology in TOEFL preparation is required, regarding personalized feedback and adaptive learning pathways. Immediate feedback, as highlighted in these studies, plays crucial role for enhancing retention, cognitive development, and overall academic performance.

Conclusion

This study indicates that the use of the web-based TOEFL ITP test has significantly improved learners' learning outcomes and motivation. Data analysis revealed a clear improvement for pre-test and post-test scores, with 79% learners achieving minimum score of 500 after using the platform, compared to only 43% passing in the pre-test. Feedback from learners also showed that the design and functionality of the website supported a better learning experience, with high average scores for text clarity and menu presentation. This suggests that the platform is not only effective in enhancing English language skills but also in boosting learners' motivation to learn. The findings imply that integrating technology into assessment can enhance the effectiveness of English language teaching and provide a platform that supports independent learning. With good design and high accessibility,

the web-based TOEFL ITP test could serve as a viable alternative for language instruction in the future. However, this study has limitations, including a small number of participants and a single testing location; hence, upcoming study is recommended to involve more diverse sample and to explore other factors that may affect learners' learning outcomes, such as differences in student characteristics and teaching approaches used.

Despite the positive outcomes, the findings do not fully account for all dimensions of writing development. Improvements were primarily observed in linguistic accuracy and structural complexity, while higher-level rhetorical skills such as argument development and critical stance were not directly examined. This suggests that input-based instruction, although effective for supporting linguistic resources, may need to be complemented by process-oriented or genre-based approaches to foster more advanced aspects of academic writing. Furthermore, the reliance on short-term post-test measures limits conclusions regarding the durability of learning gains.

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Enhancing Fraction Problem-Solving Skills through the PISA-Based Design Thinking Process for Grade 5 Students

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ABSTRACT

This classroom action research asked whether a five-stage design-thinking process empathize, define, brainstorm, prototype, and test could help Grade 5 students solve problems in fraction operations when each stage was tied to one of the three dimensions of mathematical literacy in the PISA framework (formulate, employ, and interpret evaluate). Following the Kemmis and McTaggart model, the teacher-researcher ran the intervention over two cycles, eight hours in all, with 14 purposively selected fifth-graders at a medium-sized school in Somdet District, Kalasin Province, Thailand. The data came from the design-thinking lesson plans, PISA-aligned activity sheets, learning-reflection forms, and two essay tests covering the three dimensions. Three experts judged the instruments suitable (mean appropriateness above 3.51 on a 5-point scale), and item objective congruence was acceptable (IOC above 0.50; test IOC from 0.67 to 1.00). Because the study used only descriptive statistics, the results are reported as observed gains rather than statistically significant effects. From Cycle 1 to Cycle 2 the mean score rose on every dimension formulate from 75.00% to 86.58%, employ from 75.22% to 87.78%, and interpret evaluate from 75.67% to 87.44% while the overall mean climbed from 70.12% to 79.88% and the share of students meeting the proficiency criterion grew from 57.14% to 71.43%. Within this single classroom, then, mapping the design-thinking stages onto the PISA dimensions appears to give fraction instruction a workable structure. Because the design was small and single-group, the findings are exploratory and should be read with caution.

Keywords: Design Thinking Process, PISA Mathematical Literacy, Problem-solving Dimensions, Fraction operations, Classroom Action Research

Introduction

Problem solving sits at the heart of the mathematical competence that 21st century schooling is meant to build. To measure that competence across countries, the Organisation for Economic Co-operation and Development (OECD) created the Programme for International Student Assessment (PISA), which treats mathematical literacy as the ability to frame problems, reason through them, and interpret solutions in real situations (Tririnika et al., 2024). Thailand has accepted that stronger mathematics is essential if its students are to meet international standards (Arpa & Çavur, 2024), yet PISA results keep exposing weaknesses: performance varies with grade level and growth mindset (Setiawan & Kismiantini, 2025) and is pulled by economic, social, and cultural factors such as access to ICT and parental support (Ulkhag, 2024). The framework spans content, cognitive processes, contexts, and competencies (Kir & Aksu, 2024), and it describes mathematical literacy along three dimensions formulate, employ, and interpret evaluation. Strengthening these is a policy priority at home and abroad, since the same literacy underlies both PISA and Thailand's Basic Education Core Curriculum and shapes how far students can reason about and use mathematics in real contexts.

Teaching fifth-grade mathematics in the Somdet District School Group (Kalasin Primary Educational Service Area Office 3), the researcher kept meeting the same trouble with fractions. On a classroom review, more than 60% of the students could not work word problems that add or subtract fractions. They struggled to see equivalent fractions, to find common denominators, and to connect the procedures to everyday life. This echoes a wider pattern among Thai primary students, whose main difficulties appear in expressing equal parts and in addition and subtraction (Dalimunthe & Amelia, 2025). Seen through the PISA dimensions, the problem was not only weak fraction knowledge but

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weak analysis and application. One task makes this concrete. Asked to combine $\frac{3}{4}$ of one cake with $\frac{5}{8}$ of another and say how much was left after sharing, students faltered at every dimension. In formulation, they tied the situation to fractions only loosely and could not write it as a correct expression. In employ, they tried to add the amounts without first making the denominators alike not seeing, for example, that $\frac{3}{4}$ has to become $\frac{6}{8}$ before it can join $\frac{5}{8}$. In interpret evaluation, they never checked whether the leftover amount made sense.

Misconceptions take hold when teaching is too loosely planned to link the concrete to the abstract (Safira & Harun, 2024). In this classroom the usual lessons were teacher-led demonstration and drill, which did little for conceptual understanding (Dalimunthe & Amelia, 2025). Design thinking was chosen not as a generic active-learning label but because its stages line up with the weaknesses just described. Empathize and define push students toward formulation: they have to read an authentic context and state the problem mathematically. Brainstorm and prototype work on the dimension of employment, as students generate and try out more than one strategy. Test addresses interpret evaluation through checking and justification. Design thinking has produced large effects on mathematical problem solving (Harpeningtyas et al., 2025; Panikar et al., 2025). Even so, although design thinking and the PISA framework have each been studied, few studies map the two onto each other stage by stage for primary fraction learning the gap this study sets out to fill.

Literature review

The review runs along three strands and the links between them: the PISA mathematical-literacy framework and its three dimensions; documented difficulties in fraction learning, and how each map onto a dimension; and the design-thinking process, with the reasoning for aligning its stages with those dimensions. Together the strands lead to the study's conceptual framework, in which each design-thinking stage targets one dimension of fraction problem-solving.

In keeping with the Thai curriculum's 21st century competencies (Dewi et al., 2020), the PISA framework addresses mathematical content as well as cognitive processes, contexts, and competencies (Kir & Aksu, 2024). PISA assessments have proven predictive, with mathematical self-efficacy significantly predicting academic achievement (Huang et al., 2024). The framework operationalizes mathematical literacy on three dimensions: Formulate assesses students' identification of mathematical structures and translation of context into representations (Mufidah et al., 2025); Employ assesses the application of concepts and procedures, with evidence that students who develop both conceptual understanding and procedural fluency show superior long-term retention and transfer (Hidayah & Murti, 2025); and Interpret Evaluate assesses interpretation of results and judgment of reasonableness (Kurino et al., 2024).

Thailand's Basic Education Core Curriculum states that fifth-grade students must add and subtract fractions with like and unlike denominators and apply operations to real-life situations (Dewi et al., 2020), drawing on equivalent fractions, common denominators, procedural fluency, and authentic application. Good instruction moves from concrete manipulatives to symbolic notation (Farra et al., 2024), and multiple representations and collaborative problem solving are essential at this age (Ndiung & Menggo, 2024; Safira & Harun, 2024). Research shows that students often memorize procedures without grasping the underlying relationships, producing recurring computational errors (Indrawati, 2025); difficulty increases with unlike denominators, where students must treat the common denominator as a structural requirement rather than an arbitrary rule (Kontorovich & Zazkis, 2017).

Read against the PISA dimensions, these difficulties are not merely procedural: failing to recognize the underlying structure of a fraction situation is a formulate weakness; relying on memorized steps without conceptual grounding is an employ weakness; and not checking the reasonableness of an answer is an interpret evaluate weakness. This mapping motivates an instructional approach that targets each dimension directly. Design thinking comprises five iterative stages resembling advanced problem-solving processes (Panikar et al., 2025). It recognizes multiple solution pathways, supporting diverse learners (Erenea & Sarmiento, 2025) within a psychologically safe environment (Tririnika et al., 2024). Empathize identifies meaningful contexts and others' viewpoints, driving motivation by

linking ideas to real-world experiences (Erenea & Sarmiento, 2025). Define requires clear articulation of the problem, improving solution accuracy and strategic flexibility (Kir & Aksu, 2024; Rohmah et al., 2023). Brainstorm (Ideate) explores varied methods, fostering computational thinking and cognitive flexibility (Indrawati, 2025; Ndiung & Menggo, 2024). Prototype implements solutions as concrete artifacts, supporting deeper understanding and metacognition. Test compares solutions against the original parameters, enhancing precision through systematic validation and self-reflection (Syifah & Maharbid, 2025). Students move through concrete, iconic, and symbolic representations following Bruner's representation theory (Farra et al., 2024), in an iterative rather than strictly linear process (Panikar et al., 2025).

Conceptually, the study folds the design-thinking stages into the PISA dimensions: empathize and define serve formulate; brainstorm and prototype serve employ through multiple representations and hands-on solutions; and test serves interpret evaluate through checking and reflection (Kir & Aksu, 2024; Panikar et al., 2025). Direct tests of this exact pairing are still scarce, but two lines of evidence make it plausible. First, the five-stage process has been shown to sharpen problem-solving: Nguyễn et al. (2025) found that bringing design thinking into STEM teaching markedly improved high-schoolers' problem-solving, with strong links between stages (define ideate, prototype test) that point to the worth of the iterative cycle. Second, the PISA 2022 framework itself encourages joining structured thinking to mathematical literacy, which is what Rahmawati et al. (2024) did when they built computational thinking into that framework for primary mathematics. Read together, the two suggest it is feasible to embed a structured thinking process in the PISA dimensions the pairing this study works out for design thinking in fraction learning. PISA-Based Design-Thinking Process refers, in this study, to a five-stage instructional sequence (empathize, define, brainstorm, prototype, test) in which each stage is deliberately mapped to a targeted PISA dimension empathize/define to formulate, brainstorm/prototype to employ, and test to interpret evaluate and is enacted iteratively across two action research cycles, with Cycle 2 refined from Cycle 1 reflection data. Fraction Problem Solving Skills refers to students' performance on multi-part word problems involving addition and subtraction of fractions, scored on an analytic rubric across the three PISA dimensions: formulate (recognizing and translating the situation into mathematical form), employ (selecting and executing fraction concepts and procedures), and interpret evaluate (interpreting the result and judging its reasonableness in context), each rated 0-3.

Evidence supports innovative pedagogy in mathematics: problem based learning markedly increased creative thinking and problem solving with large effects (Ndiung & Menggo, 2024); concrete manipulatives outperformed abstract-only instruction in fraction operations (Farra et al., 2024); Realistic Mathematics Education was as effective as or more effective than traditional instruction (Ventistas et al., 2025); and a systematic review reported positive design thinking outcomes across cognitive, affective, and behavioral domains (Yu et al., 2024).

Research Objectives

This action research set out to build Grade 5 students' PISA-based problem-solving in fraction operations across the formulate, employ, and interpret evaluate dimensions through a design-thinking process run over two action-research cycles.

Research methodology

Research Design

This study used a classroom action research design based on the Kemmis and McTaggart cyclical model (Kemmis & McTaggart, 1988). The cycle is iterative, comprising planning, action, observation, and reflection (Efendi et al., 2025). Action research is an empirically supported framework for identifying and resolving genuine classroom problems, empowering teachers to deploy systematic interventions and validate their impact in real teaching learning situations (Cierpiłowska, 2023). Its cyclical nature allows iterative modification based on data collected over time, making it well suited to evaluating innovative pedagogies such as design-thinking-based learning (Ona & Purwanta, 2025; Torun & Pektaş, 2025).

Participants

The study took place in a medium-sized primary school in the Somdet School District (Kalasin Primary Educational Service Area Office 3), Kalasin Province, Thailand, where the students come from a rural area and a range of backgrounds and where the ordinary classroom had room and materials for group work. Fourteen fifth-graders in the first semester of 2025 took part. They were chosen purposively from earlier surveys of low mathematics achievement and observed trouble with fractions; these criteria reflect general performance rather than tested weakness in the specific PISA dimensions a limitation noted later. A small, purposive group of this kind suits classroom action research, which favors depth and adaptability over size (Amelia et al., 2025).

Data Collection Tools

Four data collection instruments were constructed and validated:

1. Design Thinking Lesson Plans

Four lesson plans, each two hours, carried the five-stage model (Panikar et al., 2025), eight hours in all. Plans 1-2 (Cycle 1) introduced adding and subtracting fractions; Plans 3-4 (Cycle 2) moved to multi-step word problems. Every plan worked from concrete activities (fraction blocks, number lines, paper folding) through visual models (area models, tape diagrams) to symbolic procedures (Farra et al., 2024). The content differed between cycles, but both were assessed with parallel essay tests built on the same rubric and the same three dimensions, so performance was compared on a common construct rather than on identical items.

2. Learning Activity Sheets

Each lesson had one activity sheet, four in all, with four to six tasks tied to the five stages and the PISA dimensions. The prompts scaffolded three moves: (a) restate the situation in the student's own words and name the quantities (formulate); (b) carry out more than one strategy with concrete or visual representations (employ); and (c) check and justify the answer (interpret evaluate). One task, for instance, set out two pizza trays one cut into 8 pieces, plus 3 pieces from a second tray cut into 4 and asked for the total as a fraction, with the method shown. Because the pieces are different sizes, they cannot simply be counted, so the single task draws on all three dimensions: writing the situation as a fraction and noticing the unlike denominators (formulate), rewriting $\frac{3}{4}$ as $\frac{6}{8}$ and adding to get $\frac{8}{8} + \frac{6}{8} = \frac{14}{8} = \frac{7}{4}$ (employ) and judging whether about one and three-quarter trays is reasonable (interpret evaluate).

3. Learning Reflection Forms

A reflection form at the end of each cycle asked students what they had learned, how they had solved problems, and where they had struggled. It mixed 5-point Likert items (engagement, confidence, perceived learning) with open questions. The form did double duty a learning activity that supported metacognition, and a data source on the difficulties students reported in each dimension; the open responses were coded thematically and cross-checked against test scores and field notes.

4. Mathematics Problem-Solving Skill Tests

Two parallel essay tests assessed fraction problem-solving per the PISA framework. Each test was built on a single authentic situation comprising five multi-part items, mapped through a test blueprint (table of specifications) to ten PISA sub-skills across the three dimensions four under formulate (1.1-1.4), three under employ (2.1-2.3), and three under interpret evaluate (3.1-3.3). These tasks reflect key PISA features: an authentic context, the translation of a situation into mathematical form, the use of multiple representations, and an explicit demand to interpret and justify the result. For dimension-level analysis, analytic rubric rated each sub-skill on a 0-3 scale (0 = no evidence, 1 = partial, 2 = adequate, 3 = complete), and each dimension score was reported as the meaning of its sub-skill ratings (Table 3). Separately, each student was assigned an overall test score out of a maximum of 60 points, which was converted to a percentage (Table 2) and classified by the Thai educational quality-level standards (Office of the Basic Education Commission, 2018): $\geq 80\%$ very good, 70-79% good, 60-69% fair, 50-59% needs improvement, $< 50\%$ poor.

5. Expert validation and scoring

Three experts in mathematics education, elementary instruction, and assessment evaluated the lesson plans on six dimensions (content validity, learning management, media/resources, measurement and evaluation, language fit, and integration of design thinking) using a 5-point scale (Srisa-ard, 2010); plans with a mean ≥ 3.51 from all experts were accepted. Activity sheets and tests were examined using the Index of Item-Objective Congruence (IOC: +1, 0, -1), with items ≥ 0.50 considered aligned. All lesson-plan means exceeded 3.51, and all test items exceeded the 0.50 criterion, with IOC values ranging from 0.67 to 1.00. Each essay test was scored by two raters using the analytic rubric; the raters reviewed responses together and resolved discrepancies through discussion to reach a consensus score for each dimension.

Data Collection Procedures

Two complete action-research cycles were carried out in August 2025, each using the Kemmis and McTaggart phases. Table 1 presents the schedule.

Table 1 Organization of learning activities across research cycles

Cycle	Lesson Plans	Subject Matter	Date	Hours
1	1 and 2	Adding and Subtracting Fractions	Aug 14-15, 2025	4
2	3 and 4	Problem-Solving with Adding/Subtracting Fractions	Aug 18-19, 2025	4

Each validated instrument entered the process at a defined point, so that the data-collection procedure was carried out through the data-collection tools rather than separately from them. Before the cycles began, the three experts validated the instruments (expert validation and scoring): the design-thinking lesson plans were rated on the six-dimension 5-point scale, and the activity sheets and the essay tests were screened with the Index of Item-Objective Congruence, so that only validated instruments were taken into the field. Within each cycle, the design-thinking lesson plans (Instrument 1) structured the planning and action phases: the teacher-researcher enacted Plans 1-2 in Cycle 1 and Plans 3-4 in Cycle 2 across four two-hour lessons, each lesson moving through the five stages Empathize (20 min), Define (15 min), Brainstorm (20 min), Prototype (30 min), and Test (15 min) set in real contexts such as recipe scaling, sharing resources, and measurement. As each lesson was taught, students completed the learning activity sheets (Instrument 2), whose four-to-six tasks were tied to the five stages and the three PISA dimensions; these sheets were collected at the end of every lesson and supplied in-process evidence of students' formulation, employ, and interpret evaluate work. Throughout the action and observation phases the researcher recorded field notes and verbal feedback against the staged plans to track how faithfully the five stages were carried out. At the close of each cycle, two end-of-cycle instruments completed the observation and reflection phases: students sat the cycle's mathematics problem-solving skill test (Instrument 4) one of the two parallel essay tests which two raters scored with the analytic rubric to produce the three dimension scores and the 60-point total, and they then completed the learning reflection form (Instrument 3), which combined 5-point Likert items with open questions. The reflection responses, the test results, and the field notes together informed the reflection phase: the difficulty with unlike denominators that surfaced in Cycle 1, seen in students' reflections and work, led to the added scaffolding questions and extra practice built into Cycle 2, which kept the same five stages but leaned harder on the test stage to build interpret evaluate. Fidelity was judged qualitatively from these field notes rather than with a formal checklist or an adherence index, something a later study could add.

Data Analysis Procedures

Data were analysed in two strands, quantitative and qualitative, matched to the two kinds of evidence the instruments produced. The quantitative strand drew on the scores from the two parallel mathematics problem-solving skill tests. Each test was marked by two raters using the analytic rubric, which rated every one of the ten PISA sub-skills on a 0-3 scale; the raters worked through the scripts together and resolved any differences by discussion to reach a consensus score for each sub-skill. Two complementary measures were then derived for every student. The mean rubric level for each PISA dimension (formulate, employ, and interpret evaluate) was obtained by averaging the sub-skill ratings

within that dimension, giving the dimension scores reported on the 0-3 scale in Table 3; and each student's overall performance was expressed as a score out of a maximum of 60 points and converted to a percentage for the overall comparison in Table 2. Because the study used a single intact group of fourteen students with no comparison condition, the analysis was deliberately confined to descriptive statistics: no inferential tests were applied, and the results are read as observed gains rather than as statistically significant effects.

For each cycle, the mean, standard deviation, and percentage of the overall scores were computed, together with the mean percentage for each PISA dimension. Each student's overall percentage was classified by the Thai educational quality-level bands ($\geq 80\%$ very good, 70-79% good, 60-69% fair, 50-59% needs improvement, and below 50% poor), and the proportion of students reaching the proficiency criterion of 70% was recorded. The two cycles were then compared on three things: the mean scores and dimension percentages, the proportion meeting the proficiency criterion, and the distribution of students across the quality-level bands. Throughout, the dimension percentages (meaning rubric levels on the 0-3 scale) and the overall percentages (out of the 60-point total) were kept on separate bases and were not treated as directly comparable.

The qualitative strand drew on the learning activity sheets, the open-ended responses in the learning reflection forms, and the field notes, and followed the interactive model of Miles and Huberman (1984), which moves between data reduction, data display, and conclusion drawing and verification. In the data-reduction phase, the reflective records and open responses were read across both cycles and segmented, and student responses were coded against the three PISA dimensions using the same analytic rubric, so that the qualitative coding and the quantitative scoring shared a common framework. The coded material was then arranged by cycle and by dimension in summary displays, which made recurring patterns visible and allowed them to be grouped into themes. Finally, the emerging themes were checked against the test performance and the field notes a form of triangulation across the three data sources and refined where the sources diverged, so that each theme rested on more than one kind of evidence. This process produced the three themes reported in the qualitative findings and identified the recurring difficulty with unlike denominators that ran through both cycles.

Results

Quantitative Findings

Results are organized by the research objective: developing fifth-graders' fraction problem-solving across the PISA dimensions through design-thinking instruction.

Table 2 Overall performance comparison between cycles

Cycle	N	No. of students scoring full marks	Mean Score	Mean %	SD	Met Criteria
1	14	1	42.07	70.12	11.94	8 (57.14%) - good
2	14	3	47.93	79.88	10.76	10 (71.43%) - good

Table 2 shows overall performance rising from 70.12% in Cycle 1 to 79.88% in Cycle 2, just short of the very-good band; the share meeting the proficiency criterion ($\geq 70\%$) grew from 57.14% (8 students) to 71.43% (10 students).

Table 3 Performance on PISA dimensions by cycle

PISA Dimension	Cycle Mean	1	Cycle 1 %	Cycle Mean	2	Cycle 2 %	Improvement
1. Formulate	2.25/3		75.00%	2.60/3		86.58%	+11.58%
2. Employ	2.26/3		75.22%	2.63/3		87.78%	+12.56%
3. Interpret Evaluate	2.27/3		75.67%	2.62/3		87.44%	+11.77%
Average	2.26/3		75.30%	2.62/3		87.27%	+11.97%

Table 3 shows improvement in all three dimensions from Cycle 1 to Cycle 2. Formulation rose from 75.00% to 86.58%, employment gained the most (75.22% to 87.78%), and interpret evaluation rose from 75.67% to 87.44%. By Cycle 2 every dimension reached the very-good band ($\geq 80\%$), a mean gain of 11.97 percentage points. These dimension figures mean rubric levels on the 0-3 scale from the analytic coding; they sit on a different basis from the 60-point total in Table 2 and are not directly comparable to the overall percentages.

Table 4 Distribution of students by quality level

Quality Level	Score Range	Cycle 1 (n)	Cycle 1 (%)	Cycle 2 (n)	Cycle 2 (%)
Very Good	$\geq 80\%$	7	50.00%	9	64.29%
Good	70-79%	1	7.14%	1	7.14%
Fair	60-69%	2	14.29%	1	7.14%
Needs Improvement	50-59%	1	7.14%	2	14.29%
Poor	$< 50\%$	3	21.43%	1	7.14%

Table 4 shows that the proportion of students at the very-good level increased from 50.00% (7 students) to 64.29% (9 students), while the proportion scoring below 60% decreased from 28.57% (4 students) to 21.43% (3 students). These changes suggest improvements among both higher- and lower-performing students.

Qualitative Findings

The qualitative material came from the researcher's reflective records across both cycles, drawing on stage-by-stage notes and cycle-level logs of problems and solutions. Three themes ran through it: the conditions the design-thinking process needed in order to work, the engagement it built, and the conceptual clarity students described.

The first theme was a growing willingness among students to formulate and share mathematical ideas. In Cycle 1, the records noted that several students were initially reluctant to propose ideas during the define and brainstorm stages and hesitant to present their reasoning to the class. The teacher responded with "write-before-speak" and small-group sharing routines and by praising effort rather than correct answers. By Cycle 2, the corresponding record indicated that this reluctance had narrowed to a smaller group, addressed by reaffirming that "thinking differently is not wrong." This shift aligns with the brainstorm and prototype stages' intended role in helping students generate and voice multiple solution strategies. It matters because willingness to articulate a problem mathematically is a precondition for the kind of formulation the intervention targeted, and the reduction in reluctance across cycles ran alongside the formulate gains the rubric captured.

The second theme concerned on-task engagement and collaborative self-regulation. Both cycles recorded off-task behaviour and slow task completion. The teacher's responses evolved from establishing shared classroom rules and using competitive warm-up activities with positive reinforcement in Cycle 1 toward post-lesson self-reflection prompts (e.g., "today I did well at...") and paired work in Cycle 2, suggesting increasingly self-regulatory routines as students became familiar with the staged structure. This gradual establishment of collaborative and self-regulatory habits appeared to be a necessary condition for the staged process to function, rather than an incidental feature of the classroom context.

Alongside these behavioural routines, the reflection forms revealed a shift in students' affective engagement toward mathematics. Many students expressed that the design-thinking activities made learning more accessible and enjoyable. One student noted, "I like learning this way because it feels fun, not stressful. I can understand the steps because I get to try and fix my mistakes by myself." This suggests that the iterative prototype and test stages helped reduce anxiety and fostered a more positive disposition toward complex fraction operations.

The third theme was a growing conceptual clarity, as students described moving away from memorization toward understanding. A recurring point in their reflections was the move away from abstract memorization toward hands-on understanding. As one student put it, “I understand it now because I don’t just have to memorize the numbers. I can see what the fractions actually mean, and that makes it much easier to solve.” This remark illustrates how the stage-by-stage alignment appeared to help students bridge concrete representations and symbolic mathematical expressions, moving from a surface engagement with procedures toward a more connected understanding of the operations involved.

Across both cycles, the reflective records consistently identified the addition of fractions with unlike denominators as the central mathematical difficulty. This difficulty was addressed at the define stage through analysis of whether denominators were equal and where errors typically arose and revisited at the test stage through the requirement that denominators be made equal before addition could proceed. Its recurrence across both cycles, and its gradual decline in the rubric scores, positioned it as the clearest instance of the intervention targeting a specific conceptual gap rather than general procedural performance.

Discussion

Across the two cycles, every indicator moved in the same direction. Overall performance rose from 70.12% to 79.88%, the proportion of students meeting the proficiency criteria grew from 57.14% to 71.43%, and all three PISA dimensions improved by roughly 11 to 12 percentage points, with employ gaining the most at +12.56 points. Within a single classroom and without a comparison condition, these figures cannot establish causation, but their consistency across dimensions and across the two measurement points is worth taking seriously. A design that targeted each dimension through a specific stage would be expected to produce broadly parallel gains if the alignment was working, and the observed pattern is at least consistent with that expectation, as well as with the theoretical reasoning that design-thinking stages can support PISA-style mathematical literacy (Wulandari et al., 2025).

The employ gain warrants particular attention. Among the three dimensions, employment most directly reflects students’ ability to select and execute fraction procedures, the area in which prior research consistently identifies the deepest difficulties at the primary level (Dalimunthe & Amelia, 2025; Indrawati, 2025). The brainstorm and prototype stages asked students to generate more than one solution strategy and to work through concrete and visual representations before moving to symbolic procedures, following the concrete-to-representational-to-abstract sequence that Farra et al. (2024) found more effective than abstract-only instruction in fraction learning. The fact that the employ dimension responded most strongly is at least consistent with the theoretical reasoning behind the stage alignment, even if the study cannot confirm the mechanism directly.

The formulate gains are similarly interpretable in light of the qualitative record. Students in Cycle 1 were reluctant to articulate their mathematical reading of a problem, and the teacher’s responses, including write-before-speak routines and small-group sharing, were designed to lower that barrier. By Cycle 2 the reluctance had narrowed, and this behavioral shift ran alongside the formulate improvement captured by the rubric. The connection is suggestive rather than conclusive. It points toward a finding that matters for instruction, namely that students who struggle with fraction problems do not always lack procedural knowledge but sometimes lack the disposition and the routine to formulate the problem mathematically in the first place. The define stage, by requiring students to restate the situation and name the quantities before any calculation, may offer one way to address that gap, and it may also help students treat the common denominator as a conceptual necessity rather than an arbitrary procedural rule, as Kontorovich and Zazkis (2017) argue is essential for genuine understanding of unlike denominator operations. Whether the defined stage does so more effectively than other instructional approaches cannot be determined from this study alone.

The interpret and evaluate dimension gained least in absolute terms, though it still rose by 11.77 points and reached the very-good band by Cycle 2. This relative modesty is informative. Interpretation and justification are cognitively demanding and typically the last to consolidate in young learners

(Hidayah & Murti, 2025; Kurino et al., 2024), and eight hours across two cycles may not have been sufficient for students to fully internalize checking as a habitual part of problem-solving rather than an additional task. The test stage addressed this dimension directly, but the qualitative record suggests it was the stage where engagement was most variable and where the teacher's scaffolding was least consistent across lessons. Future designs might allocate more time to this stage or build explicit self-assessment prompts into it to strengthen its impact on this dimension.

The reduction in students scoring below 60%, from 28.57% to 21.43%, is consistent with research suggesting that structured, iterative pedagogies can support lower-performing learners in mixed-ability settings (Putri et al., 2024; Widodo et al., 2025). An important caveat applies here, however. With only 14 students, the movement of one or two individuals shifts that percentage substantially, and no reliable claim about differential effectiveness can be made on this basis. What the pattern does suggest is that the staged routine may have given lower-performing students sufficient structure to engage with problems they would otherwise have avoided, a possibility that warrants systematic investigation with larger samples.

Placed alongside the broader literature, the gains reported here are more modest than those in studies using larger samples or experimental designs (Harpeningtyas et al., 2025; Nguyễn et al., 2025), but they are consistent in direction with meta-analytic evidence supporting design thinking across cognitive, affective, and behavioral outcomes (Yu et al., 2024) and with findings that problem-based and student-centered approaches improve mathematical problem-solving at the primary level (Ndiung & Menggo, 2024). The difference in magnitude is most plausibly a function of duration and design rather than an indication that the approach is less effective. A short, single-group classroom cycle with a small purposive sample is structurally unlikely to produce the effect sizes reported in randomized or quasi-experimental studies, regardless of how well the intervention is implemented. This does not weaken the present findings so much as it clarifies what kind of claim they can support. The study offers a carefully documented account of a theoretically grounded instructional approach producing consistent improvement across a specific set of dimensions in a real classroom, and that constitutes a meaningful contribution at this early stage of research on the design-thinking and PISA pairing in primary mathematics.

A final observation merits consideration. Addition of fractions with unlike denominators was identified as the central mathematical difficulty across both cycles, and it manifested across all three dimensions simultaneously. Students struggled to recognize it as a structural problem rather than a procedural one (formulate), defaulted to adding numerators and denominators separately without converting (employ), and rarely checked whether their answers were plausible (interpret and evaluate). This cross-dimensional character of a single conceptual difficulty is precisely what a dimension-aligned instructional model is built to address, and the decline in unlike denominator errors across cycles, visible in both the rubric scores and the qualitative record, is consistent with the possibility that the staged structure helped students engage with the difficulty more systematically, though this interpretation remains tentative given the study's descriptive and single-group design.

Conclusion

This study set out to explore whether mapping the five stages of design thinking explicitly onto the three PISA problem-solving dimensions could give primary fraction instruction a workable and principled structure. Within this single classroom, the results were encouraging. Overall performance rose from 70.12% to 79.88%, the proportion of students meeting the proficiency criterion grew from 57.14% to 71.43%, and all three dimensions improved consistently across cycles. Formulate rose from 75.00% to 86.58%, employed from 75.22% to 87.78%, and interpret and evaluate from 75.67% to 87.44%, with every dimension reaching the very-good band by Cycle 2. These figures are descriptive, drawn from a small single group, and cannot be read as evidence of causal effect. What they do suggest, more modestly, is that the staged pairing produced consistent and parallel improvement across dimensions within this particular classroom context.

The theoretical contribution of the study lies in the explicitness of the pairing itself. Prior work has applied design thinking to mathematics broadly and has used the PISA framework to diagnose student performance, but the two have rarely been brought together stage by stage for a specific content

domain at the primary level. By treating empathize and defining as entry points into problem formulation, brainstorm and prototype as scaffolds for representational and procedural work, and test as a structured mechanism for interpretation and justification, the study offers a concrete and testable instructional model. The parallel gains across all three dimensions are consistent with the theoretical logic of that model, though with a sample of 14 and no comparison condition, they cannot confirm it. The qualitative record adds some texture: students described moving away from memorization toward understanding, and their growing readiness to articulate mathematical reasoning across cycles is broadly in line with the formulate gains the rubric captured, though this reading remains interpretive.

The practical value of the approach appeared most clearly around unlike denominator addition, which was the persistent difficulty across both cycles. The design-thinking structure addressed it not by adding more drills but by making the conceptual necessity of common denominators visible at the define stage and verifiable at the test stage. Whether this mechanism accounts for the gains cannot be established here, but it points to a plausible reason why a staged routine might suit fraction content specifically, given that fraction errors often reflect weak problem formulation and insufficient checking rather than procedural failure alone. The reduction in students scoring below 60%, from 28.57% to 21.43%, is also worth noting, though with only 14 students the shift of one or two individuals is enough to move that figure considerably, and no strong claim about differential effectiveness can rest on it.

The study's limitations should be bound by how far these conclusions travel. The design was small, single-group, and restricted to eight hours across two cycles; no comparison condition was possible, and novelty, maturation, and repeated-testing effects cannot be ruled out. The cross-cycle comparison assumes broadly parallel test forms whose difficulty was not formally equated. The qualitative record describes instructional process and classroom engagement rather than dimension-level conceptual change in individual student work. These constraints mean the findings are best read as exploratory: they document that the pairing is feasible in an ordinary primary classroom and that it was associated with consistent improvement, not that it caused it or that the same results would appear elsewhere.

Three directions follow with particular priority. The stage-by-stage pairing needs testing under experimental or quasi-experimental conditions with larger and more diverse samples, so that effect size and causal attribution become tractable. Longitudinal designs would establish whether the gains persist and transfer beyond the intervention window. Systematic coding of individual student artifacts within each PISA dimension would also give the qualitative strand the analytic depth it currently lacks. The present study contributes a documented, theoretically grounded starting point: the design-thinking and PISA pairing is coherent, feasible at the primary level, and merits the more rigorous investigation it has not yet received.

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