

The Impact of Analogical Learning and the Feynman Technique on English Achievement and Reasoning Ability in Grade Six : An Experimental Study

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ABSTRACT

Improving both academic achievement and reasoning ability remains a challenge in primary English education. This study examined the effects of integrating analogical learning with the Feynman Technique on Grade 6 students' English academic achievement and reasoning ability. A quasi-experimental pretest-posttest control-group design was adopted, with two intact classes selected through cluster sampling and assigned to an experimental group (n = 29) and a control group (n = 27); data were collected using an English achievement test and a reasoning ability questionnaire and analyzed using descriptive statistics and t-tests. Results showed that the experimental group significantly outperformed the control group in academic achievement, with posttest scores (M = 85.00, SD = 9.12) exceeding both their pretest scores (M = 80.31, SD = 9.72) and those of the control group (M = 79.96, SD = 9.56). Similar gains were observed in reasoning ability, as the experimental group's posttest scores (M = 70.55, SD = 9.07) were higher than their pretest scores (M = 65.38, SD = 9.80) and the control group's scores (M = 65.37, SD = 9.20), suggesting that this integrated approach effectively enhances learning outcomes in primary school English classrooms.

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INTRODUCTION

The primary objective of English education in China is to foster students' integrated thinking abilities alongside their academic performance. Chinese scholars recognize that, in practice, the insufficient integration of thinking skills training persists in primary and secondary school English classrooms (Yuan et al., 2022). Language learning is fundamentally a process of reasoning and construction, in which learners develop rule awareness through comparison, induction, and transfer (Ellis, 2015). Cognitive psychology also emphasizes that learning effectiveness depends on the structured processing of knowledge rather than the sheer quantity of materials (Sweller, 2022). As a result, exploring instructional strategies that promote higher-order processing and foster comprehension and reasoning has become a key focus of research in primary school English education.

Analogical learning is based on the structure-mapping theory in cognitive psychology and emphasizes the comparison of relationships between source and target domains by learners to facilitate knowledge transfer and deepen understanding (Lailiyah et al., 2018). Research shows that analogical reasoning is a crucial mechanism underlying both creative thinking and logical reasoning: it not only aids problem solving in mathematics and science but also improves syntactic comprehension and semantic connections in language learning (Angraini et al., 2023; Ikuta & Miwa, 2025). By comparing various linguistic structures or semantic contexts, students can progressively build mental models of language regularities, thereby enhancing their ability to apply language flexibly in new contexts. Furthermore, the analogical process has metacognitive characteristics, encouraging learners to reflect on similarities and differences, which in turn deepens their conceptual understanding of linguistic rules (Wang, 2023; Alghamdi, 2024). Goswami (2013) further suggests that this mechanism can be applied to visual contexts and multimodal learning, thereby demonstrating cross-domain transfer effects.

The Feynman Technique, introduced by Richard Feynman, focuses on learning through explanation: learners express what they have learned in their own words to assess understanding and reinforce memory (Reyes et al., 2021). Educational psychology considers this "learning by teaching" approach an effective metacognitive strategy that improves reasoning ability and transfer (Battaglia et al., 2017; Arora et al., 2017). In language learning, it aids in transforming abstract grammatical rules into intelligible semantic–logical structures, thereby supporting language internalization (Franscy & Siahaan, 2023). Research further shows that explanatory learning activities in classroom settings can enhance learners' language expression, coherence, and learning confidence (Clarita et al., 2020).

From a cognitive structural perspective, analogical learning and the Feynman Technique share closely aligned instructional goals: analogy emphasizes understanding and transfer, while the Feynman Technique emphasizes understanding and expression. Their integration can create a cycle of understanding, explaining, and re-understanding, promoting the development of more comprehensive knowledge schemas (Gust & Kühnberger, 2006). Empirical studies indicate that when students reconstruct content through self-explanation and dialogue, their English achievement and learning motivation improve significantly (Romli, 2020). Previous research also found that combining explanation with analogy enhances the reasoning performance of learners with learning difficulties, suggesting that the interaction between explanatory output and structured input aids in the grasp of complex relationships (Gray & Holyoak, 2021). In primary English classrooms, analogical activities can be introduced during grammar or discourse comprehension phases, followed by Feynman-style explanation tasks post-learning, encouraging students to verbalize abstract concepts and achieve concurrent development of language proficiency and reasoning ability (Odiljonovna

et al., 2024). This model is particularly appropriate for primary school students who have an emerging foundation in abstract logic and are transitioning from imitation to autonomous knowledge construction.

While existing studies suggest that analogical learning and the Feynman Technique can enhance cognitive processing and language comprehension, significant gaps remain (Bsharat et al., 2024; Reyes et al., 2021). Much of the existing research has examined the two approaches separately, providing limited evidence that clarifies their synergistic mechanisms within a unified framework. Furthermore, analogical learning primarily focuses on structural understanding and transfer, while the Feynman Technique emphasizes the externalization of understanding and reflective regulation; their processing pathways are distinct and should not be treated as merely parallel. Moreover, relevant empirical research has primarily focused on mathematics, science, or higher education, leaving a gap in evidence for primary school learners, particularly those in upper grades. Furthermore, research on how to systematically design a coherent sequence of analogy and explanation tasks within primary English instruction is also limited. Against this background, the present study focuses on Grade 6 students and employs an experimental design to integrate both strategies within a single instructional framework. It examines their effects on English academic achievement and reasoning ability, aiming to propose a teaching model for primary English classrooms that is both theoretically grounded and practically feasible.

Against this background, the present study is significant in both theoretical and practical terms. Theoretically, by integrating analogical learning with the Feynman Technique, this study extends existing research on instructional strategies in primary English education by examining how combined cognitive–metacognitive approaches influence not only academic achievement but also students’ reasoning ability, which has received comparatively limited empirical attention at the primary level. Practically, the findings provide evidence-based insights for English teachers seeking instructional methods that promote deeper understanding, active learning, and reflective thinking in classroom practice. To ensure a clear research focus and direction, this study addresses the following research questions: (1) Does the integration of analogical learning and the Feynman Technique significantly improve Grade 6 students’ English academic achievement compared with traditional instruction? (2) Does this integrated instructional approach significantly enhance students’ reasoning ability?

RESEARCH METHODS

Research Design

This study employed a quasi-experimental pretest–posttest design because random assignment was not feasible in the school context, and the use of intact classes allowed changes in learning outcomes to be examined through pretest and posttest comparisons. The participants were Grade 6 students, and two intact classes were assigned to the experimental and control groups. Before the intervention, both groups took an English academic achievement test and a reasoning ability scale as the pretest. The instructional intervention consisted of 20 class sessions, during which both groups followed the same content and pace. The experimental group received instruction integrating analogical learning and the Feynman Technique, while the control group continued with traditional methods. Following the intervention, a posttest was administered. Pretest and posttest results were analyzed to compare differences and changes in English academic achievement and reasoning ability between the two groups.

Participants

Participants were Grade 6 students enrolled at Jiangnan Primary School in Jiangnan, China, during the 2024 academic year. Cluster sampling was employed to select two intact classes, which were assigned to the experimental group and the control group based on existing class placement. Inclusion criteria were as follows: (1) Grade 6 enrollment at Jiangnan Primary School in the 2024 academic year, (2) good physical health and the ability to participate in all instructional activities throughout the study period, and (3) completion of both the pretest and posttest. Exclusion criteria included transferring schools or classes, prolonged absences that prevented participation in the intervention, and failure to complete the pretest or posttest or providing invalid responses.

The final sample consisted of 56 Grade 6 students, with 29 in the experimental group and 27 in the control group. In the experimental group, there were 14 boys and 15 girls, while the control group included 13 boys and 14 girls. Students in both groups were aged between 11 and 13 years, with similar age distributions and comparable mean ages (experimental group: $M = 11.97$, $SD = 0.62$; control group: $M = 11.96$, $SD = 0.65$). English proficiency levels, classified as low, medium, and high based on pretest performance, were similarly distributed across the two groups, indicating comparable baseline characteristics (see Table 1).

Table 1
Participants' Demographic Information

Item	Experimental Group	Control Group
Sample Structure		
Number of Students (n)	29	27
Boys (n)	14	13
Girls (n)	15	14
Age		
11 years old (n)	12	11
12 years old (n)	13	12
13 years old (n)	4	4
Age (M±SD)	11.97 ± 0.62	11.96 ± 0.65
English Proficiency Level		
Low (n)	9	8
Medium (n)	13	12
High (n)	7	7

Instruments

English Academic Achievement Test

English academic achievement was measured using a researcher-developed paper-and-pencil test. The test was designed based on Grade 6 English curriculum objectives and instructional content, and comprised five domains: conceptual understanding, skill application, problem-solving, knowledge application, and English reasoning. Each domain contained 20 items, for a total of 100 items. Three experts in English education and educational measurement reviewed the items, and inter-expert agreement was satisfactory, thereby supporting content validity. The same test was used for both the pretest and

posttest, with instructions and response guidelines provided in English. The internal consistency reliability was high (Cronbach's $\alpha = 0.91$).

Reasoning Abilities Assessment Scale

Reasoning ability was assessed using a self-report scale designed to measure learners' reasoning performance during learning tasks. The scale consisted of 20 items across five dimensions: problem comprehension and identification, information gathering and organization, reasoning and logical thinking, problem-solving and decision-making, and reflection and evaluation; each dimension contained four items. Responses were recorded using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), and the questionnaire was administered in Chinese. Items were reviewed by experts, who reached consensus, confirming content validity. The overall reliability was acceptable (Cronbach's $\alpha = 0.88$), with subscale alphas ranging from 0.81 to 0.86.

Intervention and Control Conditions

The instructional intervention consisted of 20 English lessons, each lasting 45 minutes, and was implemented according to the school's established syllabus and Grade 6 English textbooks. During the experiment, the same English teacher instructed both the experimental and control groups to minimize the potential influence of teaching style differences on the study outcomes. The instructional content included units on vocabulary, sentence patterns, reading comprehension, and integrated language use, delivered in phases aligned with the textbook structure.

Table 2

Teaching Process for Integrating Analogical Learning and the Feynman Technique

Stage	Time (mins)	Strategy	Teacher's Activities	Students' Activities	Output/Record
Introduction & Activation	5	Analogical Learning	Provide context/old knowledge, guide key features	Respond, give examples, summarize features	Verbal Responses
Constructing Correspondences	10	Analogical Learning	Present analogy table/diagram, explain rules	Complete exercises, confirm rules	Analogy Worksheet
Transfer Practice	10	Analogical Learning	Provide new sentences/questions, guide application	Practice (rewrite/choose/complete dialogue, etc.)	Practice Questions
Identifying Limitations	3	Analogical Learning	Point out errors, ask to identify "inapplicable" instances	Explain differences, correct errors	Tick/Short Answer
Explanation Task	7	Feynman Technique	Distribute explanation cards, set requirements	Explain concepts in Chinese, give examples	Explanation Records
Peer Questioning & Feedback	3	Feynman Technique	Provide checklist, listen and guide	Ask questions, provide examples and evidence	Question Checklist
Re-expression & Correction	5	Feynman Technique	Correct misunderstandings, clarify	Re-explain and record corrections	Correction Record
Formative Assessment & Conclusion	2	Assessment	Distribute exit slips/quiz, summarize	Complete key questions	Exit Slip

The experimental group received a researcher-designed instructional program, which systematically incorporated analogical learning and the Feynman Technique into classroom teaching. Analogy was used to help students connect new knowledge with prior knowledge,

and learning activities, such as explanations, discussions, and practice, were designed to deepen understanding and improve learning outcomes (see Table 2).

The control group followed the original instructional approach, which primarily involved teacher explanations, guided reading of texts, and practice exercises, without the deliberate inclusion of analogical learning or Feynman Technique-related strategies.

To ensure fidelity and fair comparison, both groups were kept consistent in instructional time, textbook content, homework assignments, teaching pace, and assessment timing. The researcher also performed periodic checks on implementation based on lesson plans and classroom observation records to minimize the potential impact of instructional delivery differences on study outcomes.

Data Collection

This study employed a quantitative data collection procedure. Prior to the instructional intervention, all participants completed the English Academic Achievement Test and the Reasoning Abilities Assessment Scale as pretests to establish baseline performance. The instructional intervention was then implemented over the designated teaching period. Upon completion of the intervention, the same instruments were administered as posttests to assess changes in students' academic achievement and reasoning ability. All assessments were conducted by the researcher during regular class time in the classroom setting, following standardized administration procedures. After data collection, all responses were coded and organized by the researcher, and incomplete or invalid data were excluded prior to statistical analysis.

Data Analysis

Data analysis was performed using statistical software. Descriptive statistics were initially used to analyze the mean scores and standard deviations of students' pretest and posttest results, offering an overview of their overall performance. Independent-samples t-tests were used to compare the homogeneity of the experimental and control groups on the pretest and examine differences between the groups on the posttest. Additionally, paired-samples t-tests were conducted to analyze changes within each group between the pretest and posttest. The significance level for all statistical tests was set at $\alpha = 0.05$ to evaluate the impact of the intervention on students' English academic achievement and reasoning ability.

Ethical Considerations

The study was approved by the Ethics Review Committee of N University. Before the study, the researcher explained the purpose, procedures, risks, and obtained informed consent. Participation was voluntary, and participants could withdraw at any time without consequences. Data were coded anonymously and kept confidential, used solely for academic purposes.

FINDINGS

Independent Samples t-test

To assess the homogeneity of the experimental and control groups in English academic achievement and reasoning ability before the intervention, an independent-samples t-test was performed on their pretest scores. The results revealed no significant differences between the two groups on either measure, confirming comparability at baseline.

For English academic achievement, the pretest mean for the experimental group was 80.31, compared to 80.04 for the control group, showing a negligible difference between the

two groups. The t-test result was $t = 0.106$, $p = .916$, indicating no statistical significance ($\alpha = .05$). The effect size, Cohen’s d , was 0.028 , indicating a very small effect, further confirming the similarity in academic performance before the intervention.

For reasoning ability, the pretest mean for the experimental group was 65.38 , compared to 65.26 for the control group. The statistical result was $t = 0.047$, $p = .963$, indicating no significant difference between the groups. The effect size, Cohen’s d , was 0.013 , demonstrating that the baseline performance in reasoning ability was nearly identical for both groups. Additionally, Welch’s t-test was performed to verify the results, and the findings were consistent with the standard t-test assuming equal variances, confirming the robustness of the analysis (see Table 3).

Table 3
Homogeneity Test Results of Pretest for Experimental and Control Groups

Variable	Group	n	Mean	Standard Deviation	t	p	Cohen’s d
English Academic Achievement	Control Group	27	80.04	9.58	0.106	0.916	0.028
	Experimental Group	29	80.31	9.72			
Reasoning Ability	Control Group	27	65.26	9.24	0.047	0.963	0.013
	Experimental Group	29	65.38	9.8			

Note: Welch's t-test results are consistent with the t-test of the hypothesis of equal variation.

Hypothesis Testing

To evaluate the impact of the instructional intervention on the experimental group’s English academic achievement and reasoning ability, paired-samples t-tests were performed comparing the pretest and posttest scores. The results indicated that the posttest score for English academic achievement ($M = 85.00$, $SD = 9.12$) was significantly higher than the pretest score ($M = 80.31$, $SD = 9.72$), with $t = 16.943$, $p < .05$, demonstrating statistical significance. The effect size, Cohen’s d , was 3.146 , reflecting a very large effect. Similarly, the posttest score for reasoning ability ($M = 70.55$, $SD = 9.07$) was significantly higher than the pretest score ($M = 65.38$, $SD = 9.80$), with $t = 14.044$, $p < .05$, indicating statistical significance. The effect size, Cohen’s d , was 2.608 , reflecting a large effect (see Table 4).

Table 4
Paired-Samples t-Test Results of the Experimental Group Pretest and Posttest Differences

Variable	Test	n	Mean	Standard Deviation	t	p	Cohen’s d
English Academic Achievement	Pretest	29	80.31	9.72	16.943	.000*	3.146
	Posttest	29	85	9.12			
Reasoning Ability	Pretest	29	65.38	9.8	14.044	.000*	2.608
	Posttest	29	70.55	9.07			

Note: * $p < .05$ indicates statistical significance.

To evaluate the difference in English academic achievement and reasoning ability between the two groups after the intervention, an independent-samples t-test was performed using the posttest scores of both groups as the dependent variable. The results indicated that, in terms of English academic achievement, the experimental group’s posttest score ($M = 85.00$, $SD = 9.12$) was significantly higher than the control group’s score ($M = 79.96$, $SD = 9.56$), with $t = 2.017$, $p = .049$. The effect size, Cohen’s d , was 0.54 , reflecting

a moderate effect. Regarding reasoning ability, the experimental group's posttest score ($M = 70.55$, $SD = 9.07$) was also significantly higher than the control group's score ($M = 65.37$, $SD = 9.20$), with $t = 2.121$, $p = .039$. The effect size, Cohen's d , was 0.567 , reflecting a moderate-to-large effect (see Table 5).

Table 5

Independent-Samples t-Test Results of Posttest Differences of the Experimental and Control Groups

Variable	Group	n	Mean	Standard Deviation	t	p	Cohen's d
English Academic Achievement	Experimental Group	29	85	9.12	2.017	.049*	0.54
	Control Group	27	79.96	9.56			
Reasoning Ability	Experimental Group	29	70.55	9.07	2.121	.039*	0.567
	Control Group	27	65.37	9.2			

Note: * $p < .05$ indicates statistical significance.

DISCUSSION

This study examined the impact of an instructional intervention that integrates analogical learning and the Feynman Technique on English academic achievement and reasoning ability in Grade 6 students. The overall results indicated that, with similar baseline abilities between the two groups, the experimental group demonstrated greater improvement post-intervention and outperformed the control group. This suggests that the integrated teaching model had a positive effect. The significance of these results lies not only in the improvement in academic scores but also in the shift in learning strategies. Through analogical comparisons, students actively constructed language rules, and through Feynman-style explanations and peer questioning, they externalized understanding, tested it, and made corrections. This process facilitated the organization of knowledge and the coherence of reasoning. Therefore, the simultaneous improvement in academic achievement and reasoning ability is likely due to deeper cognitive processing rather than merely an increase in practice volume.

Analogical learning, by establishing structural mappings between source and target domains, helps students organize new information based on existing knowledge frameworks. From this, rules are derived, and transfer applications are made. The simultaneous improvement in academic achievement and reasoning ability in the experimental group can be seen as the result of this relational construction mechanism in the language learning context. Previous studies have similarly indicated that analogical phonics instruction enhances elementary students' reading ability by strengthening the connection between phonological forms and semantic understanding, thereby stabilizing language representation (Minotti, 2020). In Malaysian primary school English classrooms, the combined use of imagery and analogies has been shown to enhance critical thinking and logical reasoning. The commonality lies in requiring students to explain concepts using analogies and apply these correspondences to new contexts (Sasi, 2018). From a meaning-construction perspective, research on conceptual metaphors suggests that analogical meaning mapping helps transform abstract semantic structures into operable relational networks, supporting the systematic understanding of both semantics and syntax (Bade'Alwan, 2023). Thus, the evidence from previous studies, along with the results of this research, points to the same conclusion: the key value of analogical learning lies not in increasing the amount of practice,

but in facilitating transferable relational understanding and conceptual transfer abilities. This, in turn, supports more structured reasoning and better application performance.

In this study, the role of the Feynman Technique was to elevate learning to the level of explanation and verification. When students are asked to explain content in their own words, gaps in their understanding often become apparent. Through peer questioning and re-articulating their thoughts, they fill in these gaps and reorganize their understanding, leading to deeper cognitive processing and metacognitive regulation. This finding aligns with previous evidence. Experimental research has demonstrated that the use of the Feynman Technique in elementary and middle schools can enhance English performance and retention, suggesting that explanation tasks support knowledge reconstruction and transfer (Reyes et al., 2021). A systematic literature review also found that the technique enhances academic performance and learning confidence in students with learning difficulties, particularly in language subjects, suggesting that explanatory output concurrently supports conceptual clarification and motivation (Adeoye, 2023). The combination of explanation and peer feedback strengthens grammatical understanding and enhances clarity and fluency in expression, which aligns with the questioning and revision steps employed in this study. Therefore, the core value of the Feynman Technique lies in using verbal output to foster the internalization of understanding and reinforce transfer and reasoning performance through reflection and correction.

From a cognitive structural perspective, analogical learning focuses on enhancing the structural mapping between concepts, while the Feynman Technique encourages learners to externalize concepts through language and self-assessment. The integration of these two approaches fosters a cyclical process of understanding and reconstruction. In terms of classroom interaction, this arrangement resembles the jigsaw method in cooperative learning, where students alternate between roles as explainers and learners within groups, promoting concept integration and shared reasoning (Haryudin & Argawati, 2018). Moreover, when teachers systematically design a sequence of analogy and explanation tasks for Grade 6 English classrooms, both English achievement and student motivation can be improved simultaneously. This demonstrates that the connection between structural input and explanatory output holds practical classroom value (Koç & Peker, 2025). Thus, the integration of analogical learning and the Feynman Technique not only complements cognitive processing but also supports interactive mechanisms, increasing the likelihood that students will achieve both deep understanding and reasoning expression in English learning.

In primary school English classrooms, the value of analogical learning and the Feynman Technique goes beyond improving language achievement to simultaneously supporting 4C skills. For instance, when STEM-based teaching media promote students' logical reasoning and collaborative learning, their expressive abilities in analogical explanation and discussion improve significantly (Cahyana et al., 2020). Similarly, in English classrooms combining role-playing with peer explanations, students organize their thoughts and respond to peers through contextualized explanations, thereby enhancing pragmatic logic and semantic generalization skills, demonstrating the connection between critical thinking and communication (Clarita et al., 2020). Therefore, embedding explanatory learning tasks within the analogical teaching process is likely to enhance classroom participation and deepen understanding, while also fostering transferable learning qualities applicable not only to English learning but also to other cognitively demanding subjects.

CONCLUSION

This study examined the impact of an instructional intervention combining analogical learning and the Feynman Technique on English academic achievement and reasoning ability in Grade 6 students. The results indicated that, with similar baseline abilities, students in the experimental group significantly improved in both English academic achievement and reasoning ability, outperforming the control group, which used traditional teaching methods. This suggests that the integrated teaching model is effective and feasible in primary school English classrooms.

From the learning process perspective, analogical learning helped students establish structural connections and rule awareness between new and existing knowledge, while the Feynman Technique encouraged students to externalize, test, and refine their understanding through explanations and peer interactions. The combination of these two approaches transformed the language learning process from passive reception to active construction and reflection. This learning model, connecting understanding, explanation, and transfer, not only enhanced English academic performance but also fostered the simultaneous development of students' reasoning abilities.

Overall, this study provides empirical support and pedagogical insights for integrating analogical learning and the Feynman Technique into primary school English classrooms. It demonstrates that language instruction can simultaneously foster both academic achievement and cognitive skill development without increasing the teaching burden. The findings offer valuable insights for future primary school English curriculum design and related research.

This study has several limitations. First, the sample size and research setting are limited, and the generalizability of the results requires further verification in different schools and teaching contexts. Second, reasoning ability was assessed using a self-report scale, which may have been influenced by subjective perceptions. Future research could complement this with performance tasks or interview data. Additionally, this study used an integrated approach, making it difficult to differentiate the independent and interactive effects of analogical learning and the Feynman Technique. The duration of the intervention was also limited, making it challenging to assess long-term retention and transfer across contexts. Future research could further explore the mechanisms and sustainability of this instructional model through larger sample sizes, multi-group designs, and follow-up assessments.

Based on the findings, this study provides practical implications for both educators and policy makers. For educators, integrating analogical learning and the Feynman Technique into primary English instruction may promote deeper understanding and reasoning development without increasing instructional burden, and can be implemented through structured explanation and analogy-based activities. For policy makers, the findings underscore the importance of supporting instructional approaches that emphasize active learning and cognitive skill development in curriculum design and teacher professional development at the primary level.

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