Development and Content Validation of the CLEAR Module: An ADDIE-Based Mnemonic Strategy Module for Fraction Word Problem-Solving among Primary School Pupils

Mohd Azarul Bin Mohd Mokhtar*

Faculty of Human Development, Universiti Pendidikan Sultan Idris, 35900 Tanjong Malim, Perak, Malaysia

***Corresponding Author**

DOI: https://doi.org/10.47772/IJRISS.2026.100700374

Received: 20 July 2026; Accepted: 26 July 2026; Published: 01 August 2026

ABSTRACT

Fraction word problems remain one of the most persistent sources of difficulty in primary mathematics education, requiring pupils to integrate conceptual understanding of fractions with the linguistic and strategic demands of word-problem interpretation. This study reports the development and content validation of the CLEAR Module, an instructional module that operationalises a five-step mnemonic strategy (Circle, Line, Evaluate, Answer, Recheck) for fraction word-problem solving among Year Four primary pupils in Malaysia. Guided by the ADDIE instructional design model, the module's development integrated a needs analysis (semi-structured interviews with three purposively sampled mathematics education experts), a design phase grounded in an integration of Polya's problem-solving model, Piagetian constructivism, and Vygotskian social constructivism, and an evaluation phase assessing content validity and reliability. Content validity was established using both the Content Validity Index (CVI) and Content Validity Ratio (CVR), with three subject-matter experts evaluating ten module components. All components achieved an Item-Level CVI (I-CVI) and CVR of 1.00, and a Scale-Level CVI (S-CVI/Ave) of 1.00, indicating excellent content validity. Internal consistency reliability, assessed with a 16-teacher field trial over a six-week implementation period, yielded a Cronbach's alpha of .89. Teacher feedback further indicated favourable perceptions of the module's systematic structure, usability, and potential to support fraction word-problem instruction, alongside recommendations for greater question variety and simplified instructional language. The findings support the CLEAR Module as a content-valid and reliable instructional resource and offer a theoretically grounded, replicable design process for mnemonic-based mathematics modules. Limitations and directions for a subsequent effectiveness study are discussed.

Keywords: fraction word problems, CLEAR mnemonic strategy, ADDIE model, content validity, primary mathematics education

INTRODUCTION

Fractions are widely recognised as one of the most cognitively demanding topics in primary mathematics curricula worldwide, and difficulties with fraction word problems in particular have been documented across diverse educational systems (Björkhammer, 2025; Sari, 2024). Solving a fraction word problem requires pupils not only to understand fraction concepts but also to interpret linguistic information, select an appropriate mathematical operation, and execute multi-step procedures accurately (Copur-Gencturk & Doleck, 2021; López-Martín et al., 2022). These compounded demands mean that weaknesses in foundational fraction knowledge, reading comprehension, or metacognitive monitoring can each independently undermine problem-solving success (Sari, 2024).

International large-scale assessments and curriculum reform initiatives have consistently flagged fractions, and rational number reasoning more broadly, as an area requiring sustained pedagogical attention (OECD, 2024; Ministry of Education Singapore, 2025). In Malaysia, fractions form a core component of the Year Four Standard Curriculum and Assessment Document (Dokumen Standard Kurikulum dan Pentaksiran, DSKP) for Mathematics, encompassing the conversion between improper fractions and mixed numbers, addition and subtraction operations involving whole numbers and fractions, and the application of fraction concepts to real-world quantities. Despite curricular emphasis, classroom-level evidence continues to suggest that pupils struggle to translate word-problem text into the correct mathematical operations, often attempting computation prematurely without first identifying the problem's informational structure.

A recurring instructional response to such difficulties is the use of structured, step-based problem-solving strategies, most notably Polya's (1957) four-stage heuristic of understanding the problem, devising a plan, carrying out the plan, and looking back. However, primary-aged pupils often find Polya's stages abstract and difficult to retain in their original form during independent problem-solving (Hänze & Leiss, 2022; Herold-Blasius, 2025). Mnemonic devices that translate such heuristics into a more memorable, child-friendly sequence have therefore been proposed as a scaffolding mechanism that preserves the underlying problem-solving logic while increasing procedural accessibility for young learners.

This study addresses this need through the development of the CLEAR Module, an instructional module built around a five-step mnemonic strategy, namely Circle, Line, Evaluate, Answer, and Recheck, designed specifically to support Year Four pupils in solving fraction word problems. The module's development followed the ADDIE instructional design model (Branch, 2014; Dick et al., 2014) and was theoretically anchored in an integration of Polya's (1957) problem-solving model with Piagetian (1972) constructivism and Vygotskian (1978) social constructivism. This paper reports the Analysis, Design, Development, and Evaluation phases of the module's construction, with particular emphasis on the establishment of content validity and reliability prior to classroom implementation. Consistent with recommended practice in Design and Development Research (DDR), the evaluation of effectiveness through a quasi-experimental field trial is treated as a distinct, subsequent phase of this research programme and is not reported here.

Research Objectives

This study aims to:

1. Identify, through expert needs analysis, the instructional requirements that should inform the design of a module supporting fraction word-problem solving among Year Four pupils.
2. Develop the CLEAR Module based on the ADDIE instructional design model, integrating the CLEAR mnemonic strategy with Polya's problem-solving model and constructivist learning theory.
3. Establish the content validity of the CLEAR Module using the Content Validity Index (CVI) and Content Validity Ratio (CVR).
4. Determine the reliability of the CLEAR Module through a field trial involving practising mathematics teachers.
5. Examine teachers' perceptions of the CLEAR Module following classroom trial use.

LITERATURE REVIEW

Fraction Word Problems as a Persistent Learning Challenge

Difficulty with fraction word problems is well documented across educational contexts. Pupils frequently struggle to identify the operation implied by a word problem's linguistic structure, to distinguish relevant from irrelevant numerical information, and to apply fraction operations procedurally once an operation has been selected (Copur-Gencturk & Doleck, 2021; López-Martín et al., 2022). These difficulties are compounded for pupils with weak foundational knowledge, including incomplete mastery of multiplication facts and unclear understanding of numerator-denominator relationships (Sari, 2024). Beyond cognitive demands, affective factors such as low motivation and mathematics avoidance behaviours have also been implicated in sustained underperformance on fraction tasks (Björkhammer, 2025).

Heuristic and Mnemonic Strategies in Mathematical Problem-Solving

Heuristic strategies that make problem-solving steps explicit have been shown to reduce procedural errors and support more systematic mathematical reasoning (Hänze & Leiss, 2022; Herold-Blasius, 2025). Worked examples and explicit strategy instruction, in particular, help learners construct stronger connections between mathematical concepts and the procedures used to apply them (Hänze & Leiss, 2022). Metacognitive strategies, including planning, monitoring, and the reflective evaluation of one's own solution process, are similarly associated with improved problem-solving performance, as learners who actively check and revise their answers outperform those who rely on a single attempt without verification (Bal & Doğanay, 2022; Sercenia & Prudente, 2023).

Mnemonic techniques that compress multi-step heuristics into a memorable acronym are a recognised pedagogical adaptation for younger learners, for whom abstract multi-stage models can be difficult to retain and apply consistently (Herold-Blasius, 2025). The CLEAR strategy at the centre of this study draws on this rationale, translating Polya's (1957) four problem-solving stages into a five-step sequence specifically scaffolded for primary-level fraction word problems.

Theoretical Framework: Integrating CLEAR, Polya, and Constructivism

The development of the CLEAR Module is grounded in the integration of three theoretical perspectives: Polya's problem-solving model, Piagetian constructivism, and Vygotskian social constructivism. Each is discussed in turn below, followed by an account of how the three are integrated within the CLEAR strategy itself.

Polya's Problem-Solving Model

Polya (1957) proposed four sequential stages for mathematical problem-solving: understanding the problem, devising a plan, carrying out the plan, and looking back. While extensively used in mathematics education, primary-aged pupils often find it difficult to consistently apply these stages without more concrete scaffolding (Herold-Blasius, 2025).

Piagetian Constructivism

Piaget (1972) proposed that learning occurs through the complementary processes of assimilation and accommodation, whereby learners actively restructure their understanding in response to new information. Within the CLEAR framework, pupils actively identify key information, interpret the problem's demands, and construct their own solution strategy prior to computation, a process consistent with active knowledge construction.

Vygotskian Social Constructivism

Vygotsky (1978) emphasised the role of social interaction and guided support in cognitive development, formalised through the concept of the Zone of Proximal Development (ZPD). The CLEAR Module operationalises this principle by enabling teachers to provide scaffolding through worked examples, step-by-step guidance, and collaborative activities that support pupils' progression from their current level of understanding toward independent mastery.

Integration within the CLEAR Strategy

Table 1 maps each CLEAR step to its corresponding stage in Polya's model, the relevant constructivist mechanism, and the associated learning outcome. Figure 1 presents the complete conceptual framework, showing how the needs analysis findings, the ADDIE model, the three theoretical foundations, the CLEAR mnemonic steps, the resulting module components, and the intended learning outcomes are integrated into a single coherent design logic.

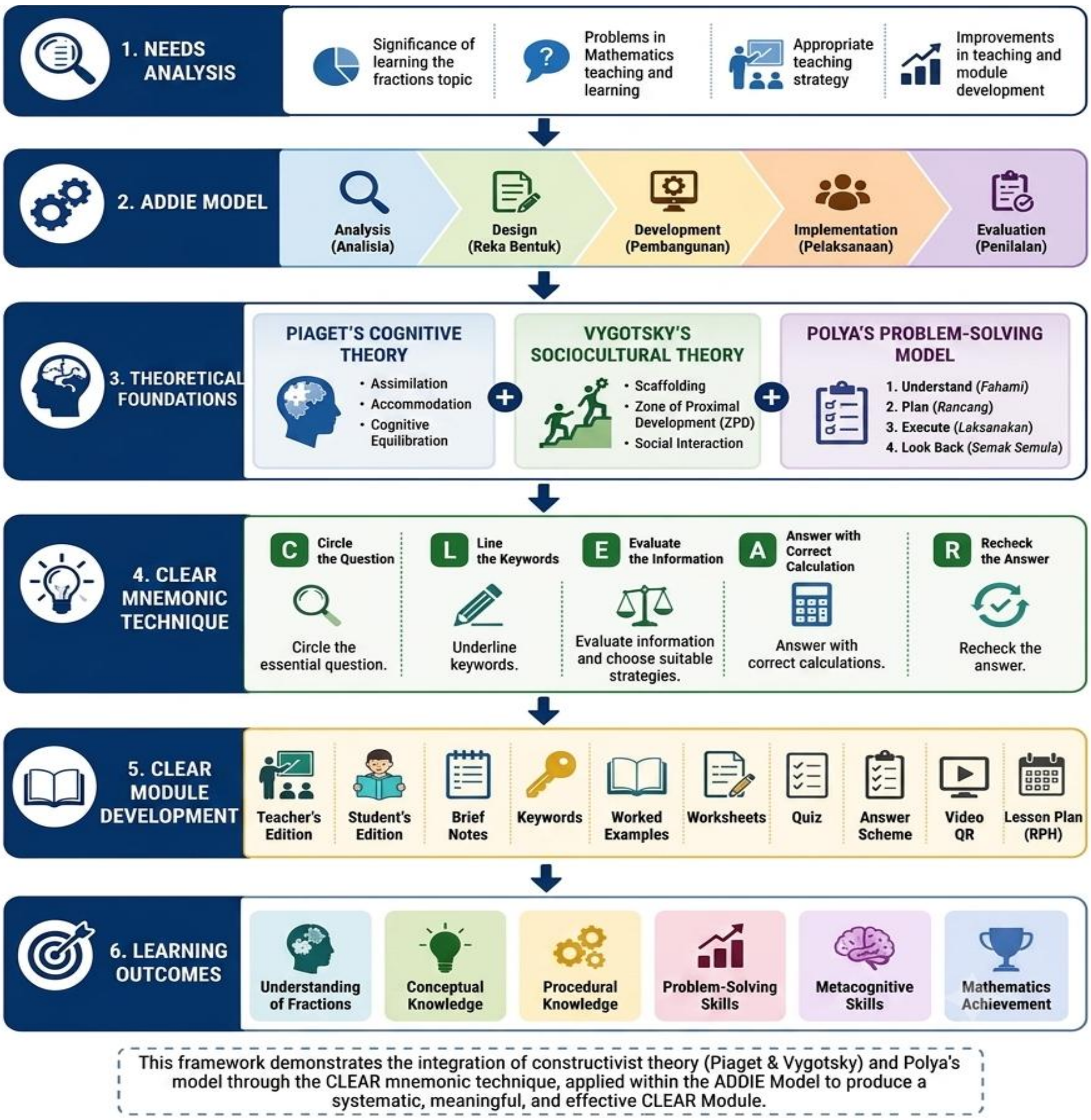
Table 1 Integration Map: CLEAR Steps, Polya's Model, Piaget, Vygotsky, and Learning Outcomes

CLEAR Step	Polya's Stage	Piaget	Vygotsky	Learning Outcome
Circle (mark what the question asks)	Understand the Problem	Assimilation of new information	Teacher guidance in identifying the question's demand	Problem comprehension

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

CLEAR Step	Polya's Stage	Piaget	Vygotsky	Learning Outcome
Line (underline keywords)	Understand the Problem	Information organisation	Scaffolding to identify key information	Information encoding
Evaluate (assess information and select operation)	Devise a Plan	Accommodation and reasoning	Discussion and guidance within the ZPD	Strategy selection
Answer (carry out the calculation)	Carry Out the Plan	Concrete operational thinking	Teacher support as needed	Problem resolution
Recheck (verify the answer)	Look Back	Metacognitive reflection	Self-regulation	Answer accuracy

Figure 1 Conceptual Framework Integrating Needs Analysis, the ADDIE Model, Theoretical Foundations, and the CLEAR Mnemonic Strategy in the Development of the CLEAR Module



Note. Figure adapted from the original module development chapter. The framework illustrates how needs-analysis findings, the ADDIE model, constructivist and Polya-based theory, and the CLEAR mnemonic strategy jointly informed the components of the developed module and its intended learning outcomes.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

The first two steps, Circle and Line, function as a problem-orientation phase aligned with Polya's understand-the-problem stage. At this stage, pupils activate prior knowledge and engage in assimilation as conceptualised by Piaget. The Evaluate step supports reasoning and strategy selection, involving accommodation as pupils construct new schemas for situations not previously encountered. The Answer step emphasises strategy execution, supported by teacher scaffolding consistent with Vygotsky's ZPD. Finally, the Recheck step promotes metacognitive reflection, encouraging pupils to verify their answers and develop awareness of their own reasoning processes. Through this integration, the CLEAR strategy functions not merely as a mnemonic aid for recalling problem-solving steps, but as a metacognitive strategy that supports active and meaningful knowledge construction.

Table 2 CLEAR Steps Mapped to Cognitive Skills and Learning Outcomes

CLEAR Step	Cognitive Skill	Learning Outcome
Circle	Identifying the question's demand	Problem comprehension
Line	Identifying key information	Information analysis
Evaluate	Selecting the appropriate operation	Mathematical reasoning
Answer	Executing the strategy	Problem resolution
Recheck	Reflection and verification	Metacognition and answer accuracy

This theoretical integration aligns with recent research demonstrating that explicit problem-solving strategies improve pupils' ability to monitor their own thinking, reduce procedural errors, and build confidence in mathematical problem-solving (Bal & Doğanay, 2022; Sercenia & Prudente, 2023). The development of the CLEAR Module is therefore consistent with current research trends in mathematics education that emphasise learner-centred instruction and the cultivation of higher-order thinking skills, in line with the aspirations of UNESCO's Sustainable Development Goal 4 (SDG4) and twenty-first century mathematics curriculum reform (OECD, 2024).

METHODOLOGY

Research Design

This study adopted a Design and Development Research (DDR) approach, following the ADDIE instructional design model across its five constituent phases: Analysis, Design, Development, Implementation, and Evaluation. This paper reports the Analysis, Design, Development, and Evaluation phases, with particular focus on the establishment of content validity and reliability of the CLEAR Module prior to its use in a planned subsequent effectiveness trial.

Analysis Phase

Participants

A purposive sampling approach was used to select three mathematics education experts as key informants for the needs analysis. According to Lynn (1986), content validity assessment can be conducted using between three and ten experts depending on the scope and purpose of a study. Three experts were selected on the basis that each held more than ten years of teaching experience in primary mathematics and had direct involvement in curriculum development, assessment, or mathematics teacher professional training.

- Expert 1 (E1): Head of the Mathematics Unit at a State Education Department, with more than 15 years of teaching experience and prior experience as a trainer and examiner for the national primary mathematics examination (UPSR).
- Expert 2 (E2): Head of the Mathematics Panel at a primary school, with more than 10 years of experience teaching Year Four Mathematics.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

- Expert 3 (E3): A Level Two (upper primary) Mathematics teacher with more than 10 years of service in mathematics education.

The three experts held complementary but distinct areas of expertise, namely state-level curriculum management, school-level subject-panel leadership, and direct classroom instruction at the upper primary level, enabling a comprehensive evaluation spanning content, pedagogy, curriculum alignment, and classroom usability.

Data Collection and Analysis

Semi-structured interviews were conducted with the three experts to gather in-depth perspectives on the development of a fraction word-problem module for Year Four pupils. Interview questions focused on the importance of the fractions topic, challenges in mathematics teaching and learning, instructional strategies, and recommendations for module improvement. All interviews were audio-recorded, transcribed verbatim, and analysed thematically. Coding proceeded inductively from the interview transcripts, and codes were grouped into broader themes through iterative comparison across the three experts' responses. This process yielded four major themes: the importance of learning the fractions topic, problems in mathematics teaching and learning, instructional strategies, and recommendations for improvement. Illustrative participant excerpts supporting each theme are reported in the Needs Analysis Findings subsection and summarised in Table 3.

Design Phase

Curriculum Alignment

The CLEAR Module's learning objectives were developed in direct alignment with the Year Four DSKP Mathematics curriculum, covering conversion between improper fractions and mixed numbers, addition of up to three numbers involving proper fractions, whole numbers, and mixed numbers, subtraction involving whole numbers, proper fractions, and mixed numbers, combined addition-subtraction operations, and determining the fractional value of a given quantity. Each objective was mapped against its corresponding curriculum content and learning standard, and against the specific in-module activities designed to support it (Table 4).

Table 4 Curriculum Alignment: DSKP Content Standards, Learning Standards, CLEAR Module Objectives, and In-Module Activities

DSKP Content Standard	Learning Standard	CLEAR Module Objective	In-Module Activity
Fractions	Convert improper fractions to mixed numbers and vice versa	Pupils can accurately convert improper fractions to mixed numbers and vice versa	Concept notes, CLEAR worked examples, reinforcement exercises, quiz
Fractions	Add proper fractions, whole numbers, and mixed numbers	Pupils can solve fraction addition problems using the CLEAR strategy	Worked examples, worksheets, routine and non-routine exercises
Fractions	Subtract proper fractions, whole numbers, and mixed numbers	Pupils can solve fraction subtraction problems systematically	Step-by-step activities, enrichment exercises, quiz
Fractions	Solve combined addition-subtraction fraction operations	Pupils can select the appropriate operation and solve problems accurately	Contextual questions, graded exercises, answer scheme
Fractions	Determine the fractional value of a quantity	Pupils can apply fraction concepts to everyday situations	Real-world questions, application activities, independent exercises
Mathematical Problem-Solving	Solve word problems involving fractions	Pupils can apply the CLEAR strategy to fraction word problems	Circle, Line, Evaluate, Answer, Recheck (CLEAR)

Theoretical and Model Basis

As detailed in the theoretical framework, the design phase integrated Piagetian constructivism, Vygotskian social constructivism, Polya's problem-solving model, and the ADDIE model as the foundational theoretical basis for the module.

Implementation Strategy Planning

Implementation planning addressed teacher selection, teacher training, the implementation session, and assessment instruments, in preparation for the subsequent quasi-experimental phase of this research programme. Two Year Four mathematics teachers from a primary school in the Petaling Perdana district, Selangor, with comparable teaching experience and academic qualification, were identified for this planned phase, in which an experimental group will use the CLEAR Module and a control group will use a conventionally developed module over the duration of the fractions teaching unit. Planned assessment instruments include a fractions achievement test, post-subtopic quizzes, and a rubric assessing problem-solving skill, conceptual knowledge, and procedural knowledge, administered at pre-test, post-test, and delayed post-test points. This implementation and its outcome data are not reported in the present paper.

Module Layout and Structure

The CLEAR Module was developed in two versions, a Teacher Edition and a Pupil Edition, using Adobe InDesign and Adobe Illustrator. The module's layout comprises a front and back cover incorporating a QR code linking to a video explanation of the CLEAR strategy, a table of contents, an introduction situating the module within Malaysia's National Education Philosophy (FPK) and the Teacher Education Philosophy Document (DFPG), learning objectives and usage guidance, a mathematics word-problem keyword glossary (Pupil Edition), a sample Daily Lesson Plan or RPH (Teacher Edition), concise concept notes, worked examples and explanations of the CLEAR strategy, worksheets with 15 items per subtopic across five fraction subtopics, formative quizzes administered at the end of each subtopic, and complete answer schemes. Exercises were designed to range from routine to non-routine items, and item construction took Bloom's Taxonomy cognitive levels into account to support graduated cognitive development. Question selection drew on existing mathematics workbooks used in Malaysian schools and on recommendations from the experts consulted during the Analysis phase.

The rationale for developing a topic-specific module, rather than relying on general-purpose national curriculum materials, was that existing Ministry of Education modules cover the entirety of the primary mathematics curriculum and therefore cannot provide the depth of focus that a single-topic, strategy-specific module can offer, particularly for pupils with uneven access to supplementary digital learning resources, such as those in rural areas.

Development Phase

The Development phase translated the finalised design specifications into the completed CLEAR Module, again using Adobe InDesign and Adobe Illustrator, to ensure an optimal standard of visual design, content organisation, and usability.

Evaluation Phase

Content Validity: Content Validity Index (CVI)

Content validity assessment followed the procedure recommended by Lynn (1986), in which a panel of experts rates the relevance of each module component on a four-point scale (1 = not relevant, 2 = somewhat relevant, 3 = relevant, 4 = highly relevant). Three experts, selected for their expertise in mathematics education, module development, and instructional design, rated ten components of the CLEAR Module. Following Lynn's (1986) convention, ratings of 3 or 4 were classified as indicating relevance.

Item-Level Content Validity Index (I-CVI) was calculated as the number of experts rating an item 3 or 4, divided by the total number of experts. Scale-Level Content Validity Index (S-CVI/Ave) was calculated as the average of all I-CVI values across the ten components.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

Content Validity: Content Validity Ratio (CVR)

Content validity was additionally assessed using Lawshe's Content Validity Ratio (CVR), which quantifies the proportion of experts rating a given component as essential. CVR was calculated as the number of experts rating the item as essential, minus half the total number of experts, with this difference then divided by half the total number of experts.

Reliability

The reliability of the CLEAR Module was assessed through a field trial in which the module was distributed to 16 Year Four mathematics teachers from various states across Malaysia, who used the module in their teaching for six weeks. Data collected from this trial were analysed using Cronbach's alpha to determine internal consistency reliability.

Teacher Feedback

Following the field trial, qualitative feedback was collected from participating teachers regarding their perceptions of the module's usability, instructional design, and areas for improvement.

RESULTS

Needs Analysis Findings

Thematic analysis of the expert interviews yielded four major themes, summarised in Table 3 together with illustrative verbatim excerpts from the three experts (E1, E2, E3). Each theme is discussed in turn below.

Table 3 Themes, Sub-Themes, and Illustrative Expert Excerpts from the Needs Analysis

Theme	Sub-theme	Illustrative excerpt
Importance of learning the fractions topic	Foundation for other mathematics topics	“Fractions are connected to other mathematics topics and form the basis for mastering subsequent topics.” (E1)
	Application in daily life	“The concepts of half, quarter, and three-quarters are used in daily life and help with solving everyday problems.” (E1)
	Importance in examinations	“The fractions topic is frequently tested in examinations and must be mastered by pupils.” (E2)
Problems in mathematics teaching and learning	Weak understanding of fraction concepts	“Pupils are confused about the denominator and numerator in fractions.” (E1)
	Difficulty understanding word problems	“Pupils find it difficult to identify the important information in a mathematics word problem.” (E1)
	Weak basic mathematics facts	“If pupils have not mastered multiplication facts, they will face difficulty in problem-solving.” (E3)
	Weak prior knowledge	“Basic fraction concepts need to be retaught because pupils often forget

Theme	Sub-theme	Illustrative excerpt
		what they have previously learned." (E3)
	Pupil attitude and motivation	"Some pupils are reluctant to answer and show little interest in mathematics." (E2)
Instructional strategies	Use of concrete materials	"The use of materials that can be touched and seen helps pupils understand fraction concepts." (E1)
	Use of ICT	"Learning fractions can be strengthened through the use of technology and multimedia." (E2)
	Use of learning modules	"A module can help teachers provide systematic guidance to pupils." (E2)
	Step-by-step guidance	"Pupils need clear steps to solve mathematics word problems." (E3)
Recommendations for improvement	Use of graphics and visuals	"Attractive graphics can help pupils understand the fractions topic better." (E1)
	Variety of worked examples	"The module needs to contain a variety of examples so that pupils can master different question formats." (E2)
	Independent learning	"Clear instructions allow pupils to use the module even without the teacher's help." (E3)
	Technology integration	"Improvement can be made through the use of ICT and digital materials." (E1)

Theme 1: Importance of Learning the Fractions Topic

Experts identified the importance of the fractions topic through two main aspects: its role as a foundation for subsequent mathematics topics, and its application in daily life. As E1 explained:

> *"Fractions are connected to other mathematics topics and form the basis for mastering subsequent topics." (E1)*

Experts also highlighted that fraction concepts such as half, quarter, and three-quarters are frequently used in daily activities, and that the topic is consistently assessed in examinations. As E2 noted, the topic is "frequently tested in examinations and must be mastered by pupils," reinforcing its curricular importance.

Theme 2: Problems in Mathematics Teaching and Learning

Experts identified several recurring difficulties. The first concerned confusion regarding numerators, denominators, and the relationship between them, with E1 observing that "pupils are confused about the denominator and numerator in fractions." Closely related was a difficulty identifying key information within word problems, with E1 further noting that many pupils "find it difficult to identify the important information in a mathematics word problem," often attempting direct computation without first understanding what was being asked.

Experts also pointed to weak foundational knowledge as a contributing factor. E3 explained that "if pupils have not mastered multiplication facts, they will face difficulty in problem-solving," and added that "basic fraction concepts need to be retaught because pupils often forget what they have previously learned." Finally, motivational factors were raised by E2, who observed that "some pupils are reluctant to answer and show little interest in mathematics," a pattern that further undermined learning effectiveness.

Theme 3: Instructional Strategies

All three experts agreed that the effectiveness of mathematics learning depends substantially on the instructional strategies employed by teachers. E1 recommended the use of concrete manipulatives, noting that "the use of materials that can be touched and seen helps pupils understand fraction concepts." E2 highlighted the role of information and communication technology (ICT), stating that "learning fractions can be strengthened through the use of technology and multimedia," and further emphasised the value of structured modules, observing that "a module can help teachers provide systematic guidance to pupils." E3 emphasised the importance of explicit, step-based guidance, noting that "pupils need clear steps to solve mathematics word problems."

Theme 4: Recommendations for Improvement

Experts recommended improvements in technology integration, graphic and visual elements, and the diversity of worked examples. E1 emphasised that "attractive graphics can help pupils understand the fractions topic better," and separately suggested that "improvement can be made through the use of ICT and digital materials." E2 recommended that "the module needs to contain a variety of examples so that pupils can master different question formats." E3 emphasised the importance of clarity for independent use, noting that "clear instructions allow pupils to use the module even without the teacher's help."

These four themes directly informed the module's content, design, and implementation strategy decisions.

Curriculum Alignment

Table 4 presents the alignment between the Year Four DSKP Mathematics curriculum standards, the corresponding CLEAR Module objectives, and the in-module activities designed to address each standard, establishing the module's curriculum validity.

Content Validity Results

Content Validity Index (CVI)

Table 5 presents the Item-Level Content Validity Index (I-CVI) for each of the ten CLEAR Module components, as rated by the three-member expert panel.

Table 5 Item-Level Content Validity Index (I-CVI) for CLEAR Module Components

Module Component	Expert 1	Expert 2	Expert 3	I-CVI
Module Objectives	4	4	4	1.00
Fraction Content	4	4	3	1.00
CLEAR Strategy	4	4	4	1.00
Concept Notes	3	4	4	1.00
Worksheets	4	3	4	1.00
Quiz	4	4	3	1.00

Module Component	Expert 1	Expert 2	Expert 3	I-CVI
Answer Scheme	4	4	4	1.00
Graphics and Visuals	3	4	4	1.00
QR Video Code	3	3	4	1.00
Language and Instructions	3	4	4	1.00

Table 6 Scale-Level Content Validity Index (S-CVI/Ave) Summary

Validity Index	Value
Mean I-CVI	1.00
S-CVI/Ave	1.00
Percentage Content Validity	86.67%
Module Validity Coefficient	0.87

All ten components achieved an I-CVI of 1.00, reflecting complete agreement among the three experts that each component was relevant to the module's objectives. The resulting Scale-Level Content Validity Index was also 1.00, substantially exceeding the threshold proposed by Polit and Beck (2006) as indicating excellent content validity, and consistent with the criterion proposed by Lynn (1986) for I-CVI values reflecting full expert agreement.

Despite this high level of validity, the expert panel proposed several refinements prior to the implementation phase, including increasing the variety of worked examples, strengthening visual elements, and more clearly sequencing exercise difficulty from simple to complex.

Content Validity Ratio (CVR)

Table 7 presents the CVR values for the ten CLEAR Module components. All three experts agreed that every component was essential to the module, indicating very high consensus regarding the necessity of each module element.

Table 7 Content Validity Ratio (CVR) for CLEAR Module Components

Module Component	No. of Experts Rating as Essential	CVR
Module Objectives	3	1.00
Fraction Content	3	1.00
CLEAR Strategy	3	1.00
Concept Notes	3	1.00
Worksheets	3	1.00
Quiz	3	1.00
Answer Scheme	3	1.00
Graphics and Visuals	3	1.00
QR Video Code	3	1.00
Language and Instructions	3	1.00

Expert Qualitative Evaluation

Beyond the quantitative CVI and CVR results, experts provided qualitative evaluation across five dimensions: content appropriateness, clarity of learning objectives, effectiveness of the CLEAR strategy, suitability of activities and exercises, and overall usability for Year Four mathematics instruction. Table 8 summarises the experts' qualitative judgements and the corresponding interpretations.

Table 8 Expert Panel Qualitative Evaluation Summary

Evaluation Aspect	Expert Finding	Interpretation
Content appropriateness	Content aligns with the Year Four DSKP Mathematics curriculum and addresses fraction-topic requirements	Highly appropriate
Learning objectives	Objectives are clear, achievable, and suited to pupils' level	Highly appropriate
CLEAR strategy	The Circle, Line, Evaluate, Answer, and Recheck steps help pupils solve problems systematically	Highly appropriate
Activities and exercises	Sufficient exercises, though greater variety of word-problem types and non-routine questions is recommended	Appropriate, with refinement
Language and instructions	Instructions are generally understandable; some sentences should be simplified for lower-proficiency pupils	Appropriate, with refinement
Visuals and graphics	Design is attractive and suited to primary pupils	Highly appropriate
Teacher usability	Module helps teachers conduct more structured lessons	Highly appropriate
Pupil usability	Module supports independent learning with minimal guidance	Appropriate

Overall, the expert panel agreed that the CLEAR Module's principal strengths lay in its systematic content structure, its problem-solving strategy, and its alignment with Year Four pupils' needs. The CLEAR strategy itself, encompassing the Circle, Line, Evaluate, Answer, and Recheck steps, was identified as the component offering the greatest added value, supporting pupils in identifying problem demands, marking key information, selecting appropriate operations, executing calculations, and verifying their answers. The panel's recommendations for improvement, namely expanding the range of worked examples, more clearly graduating exercise difficulty, simplifying instructional language for lower-proficiency pupils, and strengthening visual elements through consistent use of icons, colour, and illustration, were incorporated into the module prior to the implementation phase.

Reliability

The 16-teacher field trial yielded a Cronbach's alpha of .89, exceeding the minimum threshold conventionally recommended in educational research and indicating that the CLEAR Module demonstrates high reliability and is suitable for use as a learning resource in the subsequent stages of this research programme.

Teacher Feedback

Analysis of teacher feedback following the field trial identified four main themes: instructional quality, problem-solving support, question difficulty level, and module improvement. Overall, teacher feedback was favourable. Participating teachers described the module as having a systematic content structure, being easy to use, visually appealing, and holding potential to improve pupils' understanding of the fractions topic. Teachers further reported that the step-based problem-solving process introduced through the CLEAR strategy helped pupils approach fraction word problems in a more organised manner, and that the difficulty level of the included questions was appropriate for Year Four pupils, with potential for extension to Year Five and Year Six as reinforcement material.

Suggested improvements included increasing the variety of question formats, providing more worked examples, and extending the CLEAR strategy to other mathematics topics beyond fractions.

DISCUSSION

This study set out to develop and validate the CLEAR Module as a content-valid, reliable instructional resource for fraction word-problem solving among Year Four pupils. The pattern of results, taken together, supports the module on both grounds and connects to several strands of the existing literature on heuristic instruction, mnemonic scaffolding, and module-development methodology.

Content Validity in Light of Evidence-Based Module Design

The unanimous expert agreement on both the relevance and the necessity of every module component is a stronger result than is typically reported in module-validation studies, where at least one or two components are usually flagged for removal. A plausible explanation lies in the sequencing of the design process itself. Rather than being developed first and validated afterward, each CLEAR Module component was derived directly from a specific finding in the needs analysis, for example the keyword glossary responding to experts' observations about pupils' difficulty identifying relevant information in word problems (Theme 2), and the QR-linked video responding to recommendations for technology integration (Theme 4). This close traceability between needs-analysis findings and design decisions is consistent with the broader literature on heuristic and worked-example instruction, which emphasises that explicit, well-justified problem-solving supports reduce procedural errors more reliably than generically designed materials (Hänze & Leiss, 2022; Herold-Blasius, 2025). The present findings extend this literature by showing that the same evidence-based logic can be applied not only to the design of individual worked examples, but to the architecture of an entire instructional module.

The CLEAR Strategy in Relation to Heuristic and Mnemonic Approaches to Problem-Solving

A recurring tension in mathematics education research is the trade-off between problem-solving models that are theoretically comprehensive but cognitively demanding for young learners, such as Polya's four-stage heuristic, and mnemonic devices that risk reducing problem-solving to a rote procedure rather than genuine reasoning. The CLEAR Module's design responds to this tension by treating the mnemonic not as a replacement for Polya's stages but as a developmentally appropriate restatement of them, consistent with Herold-Blasius's (2025) argument that strategy keys and similar mnemonic scaffolds are most effective when they preserve, rather than flatten, the underlying heuristic they represent. The Circle and Line steps make explicit what experienced problem-solvers do tacitly when they first read a problem, while the Evaluate, Answer, and Recheck steps preserve the planning, execution, and verification logic identified in studies of fraction word-problem strategy use (Copur-Gencturk & Doleck, 2021; López-Martín et al., 2022).

This has a practical implication consistent with the metacognitive problem-solving literature: if the Recheck step is taught as a genuine verification habit rather than a final checklist item, the metacognitive benefit associated with self-monitoring and answer evaluation documented elsewhere (Bal & Doğanay, 2022; Sercenia & Prudente, 2023) is more likely to transfer to fraction problems beyond those included in the module itself.

Convergence between Expert and Teacher Evaluation

The expert panel and the field-trial teachers converged on substantially the same set of refinements, namely greater variety in worked examples, simplified language for lower-proficiency pupils, and stronger visual scaffolding, despite evaluating the module through different lenses and at different points in its development.

This convergence is consistent with recommended practice in Design and Development Research, which treats expert content validation and field-based teacher feedback as complementary checks rather than redundant ones. It also echoes findings from the broader fractions-difficulty literature, which consistently identifies uneven foundational knowledge and limited exposure to varied problem formats as persistent barriers for primary pupils (Sari et al., 2024; Björkhammer et al., 2025), suggesting that the refinements identified here are not idiosyncratic to this module but reflect well-documented, generalisable challenges in fraction instruction.

LIMITATIONS

This study is subject to several limitations that should inform interpretation of its findings.

First, the expert panel for content validity assessment comprised three experts. While this sample size is consistent with Lynn's (1986) recommended range and with conventions in module-development research, a larger or more disciplinarily diverse panel could provide further confidence in the generalisability of the validity findings.

Second, the reliability field trial, while encompassing teachers across multiple Malaysian states, assessed teacher-reported reliability over a defined implementation period rather than direct pupil outcome data. The reliability evidence in this study therefore reflects the consistency of the module as perceived and used by teachers, not pupil-level psychometric performance.

Third, and most centrally, this study reports the Analysis, Design, Development, and content-validity and reliability components of the Evaluation phase only. It does not include pupil achievement data, experimental comparison with a control group, or other effectiveness outcomes, as this data collection constitutes a distinct, subsequent phase of the broader research programme. Consequently, the conclusions drawn here pertain to the module's content validity and reliability as an instructional resource, and should not be interpreted as evidence of instructional effectiveness on pupil learning outcomes.

Finally, the module's contextual specificity, having been developed for the Malaysian Year Four curriculum and trialled with Malaysian teachers, means that transferability to other curricular or national contexts would require further contextual adaptation and validation.

CONCLUSION

This study reported the development and content validation of the CLEAR Module, a mnemonic-strategy-based instructional module designed to support Year Four pupils in solving fraction word problems. Guided by the ADDIE instructional design model and theoretically integrating Polya's problem-solving stages with Piagetian and Vygotskian constructivist principles, the module was developed through a systematic, evidence-based design process originating in expert needs analysis. The resulting module was judged by an independent expert panel to be both relevant and necessary in every one of its components, and was received favourably by practising teachers following extended classroom use.

These findings position the CLEAR Module as a validated and reliable instructional resource, and establish a sound empirical basis for the subsequent quasi-experimental phase of this research programme, in which the module's effectiveness on pupil achievement and problem-solving skill will be evaluated against a control condition. Beyond the specific module reported here, the integration of the CLEAR mnemonic with Polya's problem-solving model and constructivist learning theory offers a transferable theoretical framework that may inform the design of similar mnemonic-based instructional interventions in other primary mathematics topics where pupils face comparable difficulties moving from word-problem text to mathematical action.

REFERENCES

1. Bal, A. P., & Doğanay, A. (2022). Problem-solving and students’ use of metacognitive skills. Educational Policy Analysis and Strategic Research, 17(4), 142–163. https://doi.org/10.29329/epasr.2022.478.7
2. Björkhammer, C., Hedman, M., Krey, A.-K., Samuelsson, J., Träff, U., & Östergren, R. (2025). Effects of a fraction intervention for students with special educational needs in mathematics. Scandinavian

Journal of Educational Research. Advance online publication. https://doi.org/10.1080/00313831.2025.2552232

3. Branch, R. M. (2014). Instructional design: The ADDIE approach. Springer.
4. Copur-Gencturk, Y., & Doleck, T. (2021). Strategic competence for multistep fraction word problems: An overlooked aspect of mathematical knowledge for teaching. Educational Studies in Mathematics, 107(1), 49–70. https://doi.org/10.1007/s10649-021-10028-1
5. Dick, W., Carey, L., & Carey, J. O. (2014). The systematic design of instruction (8th ed.). Pearson.
6. Gustafson, K. L., & Branch, R. M. (1997). Survey of instructional development models (3rd ed.). ERIC Clearinghouse on Information and Technology.
7. Hänze, M., & Leiss, D. (2022). Using heuristic worked examples to promote solving of reality-based tasks in mathematics in lower secondary school. Instructional Science, 50(4), 529–549. https://doi.org/10.1007/s11251-022-09583-8
8. Herold-Blasius, R. (2025). The role of strategy keys in enhancing heuristics and self-regulation in mathematical problem-solving: A qualitative, explorative, and type-building study with primary school students. Investigations in Mathematics Learning, 17(4), 289–308. https://doi.org/10.1080/19477503.2024.2430135
9. López-Martín, M. del M., Aguayo-Arriagada, C. G., & García López, M. del M. (2022). Preservice elementary teachers' mathematical knowledge on fractions as operator in word problems. Mathematics, 10(3), Article 423. https://doi.org/10.3390/math10030423
10. Lynn, M. R. (1986). Determination and quantification of content validity. Nursing Research, 35(6), 382–386.
11. Ministry of Education Singapore. (2025). Mathematics syllabus: Primary one to six.
12. Morrison, G. R., Ross, S. M., Morrison, J. R., & Kalman, H. K. (2019). Designing effective instruction (8th ed.). Wiley.
13. OECD. (2024). Common challenges in mathematics curriculum reform: International experiences. OECD Publishing.
14. Piaget, J. (1972). The psychology of the child. Basic Books.
15. Polit, D. F., & Beck, C. T. (2006). The Content Validity Index: Are you sure you know what's being reported? Critique and recommendations. Research in Nursing & Health, 29(5), 489–497. https://doi.org/10.1002/nur.20147
16. Pólya, G. (1957). How to solve it: A new aspect of mathematical method (2nd ed.). Princeton University Press.
17. Sari, I. P., Suryadi, D., Herman, T., Dahlan, J. A., & Supriyadi, E. (2024). Learning obstacles on fractions: A scoping review. Infinity Journal, 13(2), 377–392. https://doi.org/10.22460/infinity.v13i2.p377-392
18. Sercenia, J. C., & Prudente, M. S. (2023). Effectiveness of the metacognitive-based pedagogical intervention on mathematics achievement: A meta-analysis. International Journal of Instruction, 16(4), 561–578. https://doi.org/10.29333/iji.2023.16432a
19. Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.