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A DIFFERENTIATED METHOD FOR TEACHING PRIMARY SCHOOL PUPILS BASED ON DOMINANT MODES OF MATHEMATICAL THINKING

Abdusattorova Mohidil Sahobiddin kizi
First-year student, Fergana State University, Fergana, Uzbekistan
mohidilabdusattorova03@gmail.com

Abstract. This theoretical article proposes an evidence-informed differentiated method for teaching primary school mathematics by considering pupils' relatively dominant modes of mathematical thinking. Four working modes are described: analytical-symbolic, visual-spatial, verbal-logical, and integrative. The term "dominant mode" is used as a flexible pedagogical profile inferred from task performance, explanation, representation, and error patterns; it is not treated as a fixed learning style, neurological type, or permanent label. The study applies theoretical analysis, comparison, synthesis, and pedagogical modeling to research on mathematical proficiency, multiple representations, spatial reasoning, cognitive load, Universal Design for Learning, and formative assessment. The proposed method combines multimodal presentation, flexible grouping, cross-representation translation, differentiated tasks, manipulative and digital resources, and criterion-based feedback. Its central principle is to begin instruction from a learner's stronger representational pathway while systematically developing less-used forms of reasoning. A five-stage implementation cycle is presented: diagnostic observation, multimodal design, differentiated activity, formative monitoring, and reflective adjustment. The approach is intended to support conceptual understanding, confidence, mathematical communication, and cognitive flexibility without narrowing pupils to a single category.

Keywords: primary mathematics education, mathematical thinking, multiple representations, analytical-symbolic reasoning, visual-spatial reasoning, verbal-logical reasoning, differentiated instruction, cognitive flexibility, formative assessment, Universal Design for Learning

INTRODUCTION

Primary school mathematics creates the foundation for later learning in science, technology, and everyday quantitative reasoning. Mathematical proficiency is not a single skill; it includes conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and a productive disposition toward mathematics [1]. Pupils may reach these outcomes through different initial pathways. Some readily detect numerical and symbolic patterns, others reason more successfully through diagrams and spatial models, while another group needs verbal explanation and narrative context before formal notation becomes meaningful.

These differences are pedagogically important, but they must be interpreted carefully. Research does not support assigning students to fixed "learning styles" and matching all instruction to one preferred modality [2]. Such labels can narrow expectations and prevent learners from developing flexible strategies. In this article, the phrase dominant mode of mathematical thinking refers only to a temporary and task-dependent pattern of relative strength observed in the way a pupil represents, explains, and solves mathematical problems. All pupils are expected to develop all modes of reasoning.

The purpose of the article is to develop a differentiated method that uses pupils' stronger representational pathways as an entry point while deliberately expanding their ability to coordinate symbols, diagrams, language, and concrete models. The proposed approach is intended for primary teachers, teacher educators, and young researchers seeking a scientifically cautious alternative to one-size-fits-all instruction and deterministic cognitive labeling.

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MATERIALS AND METHODS

The study is theoretical and methodological. It uses analysis of research on primary mathematics learning, synthesis of concepts related to multiple representations and mathematical discourse, comparison of differentiated teaching strategies, and pedagogical modeling. The conceptual framework draws on studies of mathematical proficiency [1], evidence concerning the limitations of fixed learning-style matching [2], theories of multiple and semiotic representations [3, 4], the trainability of spatial skills [5], cognitive load [6], Universal Design for Learning [7], formative assessment [8], and effective mathematics teaching practices [9]. The result is a practical model rather than an empirically tested classification system.

RESULTS AND DISCUSSION

Conceptual meaning of dominant modes of mathematical thinking

Mathematical activity requires movement among different representational systems. A learner may express the same relationship through objects, drawings, words, tables, symbols, or graphs. Multiple representations become useful when the teacher makes their connections explicit and helps pupils translate from one form to another [3, 4]. On this basis, four working modes can be distinguished for instructional planning.

Table 1. Working profiles of mathematical thinking and differentiated teaching responses

Mode	Observable indicators	Productive entry points	Developmental extension
Analytical-symbolic	Quick recognition of numerical patterns; preference for equations, rules, and ordered procedures	Number patterns, symbolic puzzles, structured algorithms, missing-value tasks	Require diagrams, verbal justification, estimation, and interpretation of symbols in context
Visual-spatial	Strong use of diagrams, shapes, number lines, arrays, and spatial relationships	Manipulatives, grids, geometric models, dynamic visualizations, drawing-based problems	Translate visual relations into equations, definitions, and generalized statements
Verbal-logical	Learns through explanation, definitions, story contexts, and cause–effect language	Mathematical stories, think-aloud reasoning, discussion, sentence frames, oral comparison	Compress explanations into symbols, tables, and concise mathematical arguments
Integrative	Coordinates symbols, diagrams, and language; changes strategy according to the task	Multiple-solution problems, modeling, comparison of representations, proof-oriented questions	Deepen generalization, metacognition, creativity, and independent strategy selection

The analytical-symbolic mode is characterized by efficient work with numbers, operations, patterns, and algorithms. The visual-spatial mode is evident when a pupil understands

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relationships through shape, position, movement, arrays, diagrams, or models. The verbal-logical mode appears when mathematical meaning is constructed through definitions, explanations, stories, and logical connectors such as "if," "because," and "therefore." The integrative mode reflects flexible coordination of several representations. These modes are not mutually exclusive and may change according to the topic, prior knowledge, language proficiency, and classroom experience.

Formative diagnosis without permanent labeling

The teacher should not begin with a standardized label. A useful profile is built gradually from classroom evidence. First, pupils can solve equivalent tasks presented in symbolic, visual, and verbal formats. Second, short think-aloud interviews reveal how they interpret the problem and select a strategy. Third, error analysis identifies whether difficulty arises from conceptual misunderstanding, symbolic coding, spatial organization, language, or attention. Fourth, portfolios and observation records show whether the same pattern remains stable across several topics.

The profile should be reviewed regularly and used only to inform instruction. Flexible grouping is preferable to permanent grouping. A pupil may work in a visually supported group during one lesson and in an advanced symbolic group during another. This prevents low expectations and reflects the developmental nature of cognition. Spatial reasoning, for example, is trainable and can improve through targeted experience [5].

Multimodal and differentiated lesson design

A central principle of the method is that every important mathematical idea should be encountered through connected concrete, visual, verbal, and symbolic forms. For multiplication, pupils may organize counters into equal groups, represent the groups as an array, describe repeated addition in words, and finally write a multiplication expression. The teacher then asks pupils to explain how each representation expresses the same relationship. This translation process is more important than merely displaying several formats.

Differentiation occurs in the form of access, support, complexity, and expected independence. An analytical-symbolic learner may begin with a numerical pattern and then be required to draw a model. A visual-spatial learner may begin with an array and then write an equation. A verbal-logical learner may first explain a word problem and then reduce the explanation to mathematical notation. An integrative learner may compare several methods and determine which is most efficient under specified conditions. Local methodology literature also supports combining verbal explanation, visual representation, and systematic practice in primary mathematics teaching [11].

The aim is not to keep pupils within their strongest mode. Instruction should use that mode as an accessible entry point and then create a bridge toward less familiar forms of reasoning. This "strength-to-expansion" principle supports confidence while developing cognitive flexibility. It also reduces the risk that pupils who are strong in visualization but slower in symbolic notation will be incorrectly judged as mathematically weak.

Scaffolding, cognitive load, and productive difficulty

Tasks must be challenging enough to stimulate reasoning but structured enough to avoid unnecessary overload. Cognitive load theory shows that novice learners have limited working-memory capacity and may learn poorly when problem solving requires too many unfamiliar operations at once [6]. Therefore, the teacher can begin with worked examples, partially

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completed models, cue cards, or highlighted relationships and gradually remove support as understanding develops.

Support should be tailored to the source of difficulty. A pupil who understands a situation visually but miscodes the equation may benefit from color-linked diagrams and symbols. A pupil who follows an algorithm without conceptual understanding may be asked to build a model, estimate an answer, and explain why the procedure works. Productive struggle means sustained reasoning with appropriate support; it does not mean leaving a child alone with a task that exceeds current resources.

Mathematical discourse and flexible collaboration

Mathematical discourse is essential because explaining a strategy makes thinking observable. Purposeful questions should invite pupils to compare solutions, justify a step, identify an error, and connect representations. The teacher can use sentence frames such as "I know this because…," "The diagram shows…," and "The equation represents…" to support verbal-logical reasoning without reducing mathematical rigor. NCTM identifies the use and connection of representations, meaningful discourse, purposeful questioning, and the elicitation of evidence of student thinking as core teaching practices [9].

Group composition should be flexible. Temporary homogeneous groups can provide targeted support or advanced challenge. Heterogeneous groups can generate cognitive complementarity: a visual-spatial pupil may construct a model, an analytical-symbolic pupil may formalize the relation, and a verbal-logical pupil may articulate the reasoning. Roles should rotate so that each child practices all forms of mathematical activity rather than remaining in a preferred role.

Criterion-based formative assessment

A fair assessment system should permit different response forms while applying common mathematical criteria. A pupil may initially demonstrate understanding with a diagram, oral explanation, manipulative model, or equation, but assessment should examine the same dimensions: conceptual accuracy, strategic reasoning, representation, communication, and flexibility. Over time, pupils should be expected to translate their solution into at least one additional representation.

Formative assessment supports this process through observation checklists, exit questions, short interviews, portfolios, and analytic rubrics. Feedback should identify the successful feature of the solution and the next developmental step. Extensive evidence shows that assessment is most effective when it is embedded in instruction and used to adjust both teaching and learning [8].

Manipulatives, digital resources, and inclusive access

Polyfunctional materials are especially useful because they carry several forms of information at the same time. Cuisenaire rods, Dienes blocks, counters, fraction strips, number lines, grids, and geometric models connect quantity, shape, position, and symbol. Digital tools add movement, immediate variation, and dynamic feedback. Interactive boards and mathematics software can help pupils manipulate shapes, observe invariants, and connect graphical and symbolic forms.

Universal Design for Learning recommends proactively providing multiple means of engagement, representation, and action so that barriers are reduced before they become failure [7]. In mathematics, this does not mean simplifying the learning goal. It means maintaining a common conceptual goal while allowing varied ways to access information, express reasoning,

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and receive support. Digital resources should supplement, not replace, direct interaction with mathematical ideas and teacher-guided discussion.

Implementation cycle

1. Diagnostic observation: collect evidence from equivalent tasks, think-aloud explanations, error patterns, and portfolios; record a provisional profile rather than a permanent category.

2. Multimodal planning: define a common mathematical goal and prepare concrete, visual, verbal, and symbolic representations with explicit connections among them.

3. Differentiated activity: vary the entry point, scaffolding, complexity, and degree of independence while preserving the same conceptual standard.

4. Formative monitoring: use purposeful questions, observation, rubrics, and student reflection to identify progress and misconceptions during the lesson.

5. Reflective adjustment: regroup pupils flexibly, revise supports, and plan tasks that extend each learner from a stronger mode toward broader representational competence.

PEDAGOGICAL CONDITIONS AND LIMITATIONS

Successful implementation requires teacher competence in primary mathematics, child development, formative assessment, and the design of multiple representations. It also requires sufficient planning time, accessible materials, and a classroom culture in which different solution paths are respected. Teachers should document evidence and collaborate with colleagues when interpreting persistent learning difficulties.

The approach must not be justified through simplistic “left-brain/right-brain” explanations or treated as a clinical diagnosis. Research has shown that neuromyths are widespread among educators and can lead to inappropriate labeling and ineffective practices [10]. Likewise, evidence does not support the idea that every learner should always be taught exclusively in one preferred modality [2]. The model proposed here is therefore developmental, flexible, and evidence-informed: it uses observed strengths as instructional entry points while seeking to expand the pupil’s full mathematical repertoire.

CONCLUSION

Teaching primary school pupils with attention to dominant modes of mathematical thinking can strengthen individualized instruction when the concept is used cautiously. Analytical-symbolic, visual-spatial, verbal-logical, and integrative modes provide a practical language for observing how pupils approach a task, but they should never become fixed labels. Effective teaching begins from accessible representations and systematically builds connections among objects, diagrams, words, tables, and symbols.

The proposed method combines formative diagnosis, multimodal instruction, flexible grouping, scaffolding, criterion-based assessment, and reflective adjustment. Its expected outcomes are deeper conceptual understanding, increased confidence, improved mathematical communication, and greater cognitive flexibility. Future empirical research should test the model in primary classrooms and examine its effects on achievement, transfer, motivation, and the ability to coordinate multiple representations over time.

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