

Teaching Fractions to Develop Algorithmic Thinking in Grade 4th Students - Preliminary Experimental Findings

Huong Le Thi Thu¹, Huyen Nguyen Thi Ngoc²

¹Faculty of Primary Education, Thai Nguyen University of Education, Vietnam

²Minh Tien Primary and Secondary School, Lang Son Province, Vietnam

ABSTRACT: This study examines learning outcomes and manifestations of algorithmic thinking among Grade 4 students learning fractions through an approach that emphasizes task analysis, articulation of sequences of steps, and the execution and checking of procedures. An instructional experiment was conducted in the second semester of the 2024–2025 school year at Minh Tien Primary and Lower Secondary School, Lang Son Province, with 32 students in the experimental class and 30 in the control class. End-of-first-semester test scores served as the pre-test; both classes took the same post-test. Qualitative data were collected through observations, student work, and discussions with teachers and students. The mean post-test scores of the two classes were 8.28 and 7.40, respectively; the proportions of students scoring 8 or above were 71.9% and 46.7%. The qualitative cases illustrate students' ability to articulate sequences of steps, check their work, and correct errors. The findings provide preliminary support for the application of the strategies, within the limits of a study involving two classes.

KEYWORDS: algorithmic thinking; fractions; mathematics teaching; Grade 4 students; instructional experiment.

1. INTRODUCTION

Primary mathematics teaching should provide students with opportunities to understand mathematical content, explain their procedures, and apply their learning to appropriate tasks. The General Education Curriculum for Mathematics calls for the development of mathematical competence through students' learning activities, including mathematical thinking and reasoning, problem solving, communication, and the use of tools and resources for learning mathematics (Ministry of Education and Training, 2018). In this context, engaging students in identifying what needs to be done, articulating sequences of steps, and checking results has practical value for their learning.

Fractions and operations with fractions offer numerous opportunities to develop sequential thinking. To perform a calculation, students need to recognize the characteristics of the fractions, select appropriate transformations, carry out the operations, and check the result. Errors can arise as early as the identification of the conditions under which a rule applies. A correct solution therefore needs to be considered alongside how students develop and explain it.

Futschek (2006) argues that algorithmic thinking can be developed through task solving without necessarily learning programming. Byrka et al. (2024) approach algorithmic thinking in terms of observable and measurable components. In their research on rational numbers, Moss and Case (1999) highlight the need to consider both conceptual understanding and students' explanations when evaluating instructional outcomes. These research perspectives suggest combining test scores with evidence of the task-solving process.

The question is how to organize these activities within Grade 4 fraction instruction and document their outcomes in a specific classroom context. This paper reports an experiment involving a set of instructional strategies comprising knowledge exploration, mathematical problem solving, and the use of Scratch to support learning. The study addresses two questions: (1) What learning outcomes do the two classes demonstrate before and after the experiment? (2) How do students in the experimental class demonstrate algorithmic thinking through learning activities and student work?

2. THEORETICAL BACKGROUND

2.1 Algorithmic thinking in Grade 4 mathematics learning

The ability to solve a task through a clear sequence of steps is an important consideration in conceptualizing algorithmic thinking. Futschek (2006) emphasizes the potential to develop this form of thinking through problems with readily understandable requirements and visual representations. Byrka et al. (2024) clarify the knowledge, skills, and abilities that can be observed in

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algorithmic activities. As these studies are primarily situated in computing or higher education, their application to primary education requires adjustments to tasks, language, and levels of demand.

In this study, algorithmic thinking is understood as a process in which students analyze a mathematical task, identify and organize what needs to be done into a clear sequence, and execute, check, and adjust the procedure to obtain an appropriate result; they also begin to articulate a general procedure and apply it to similar tasks. The concept is specified through five manifestations: (1) analyzing the task and identifying what needs to be done; (2) constructing and articulating steps in a logical sequence; (3) carrying out the task according to the established sequence; (4) checking, identifying, and correcting errors; and (5) reflecting on the procedure, articulating a general procedure, and applying it to similar tasks.

These five manifestations serve as the basis for selecting activities and analyzing qualitative data. Within a task, they may overlap and emerge to varying degrees. Students may express their thinking verbally, through symbols or drawings, or by manipulating learning materials. Teachers need to consider both what students can do and their ability to explain and adjust their procedures, while selecting an organizational approach appropriate to each type of activity.

2.2 Opportunities to develop algorithmic thinking through fraction instruction

According to the General Education Curriculum for Mathematics, Grade 4 content includes recognizing fractions, the basic property of fractions, simplifying fractions in simple cases, comparing fractions, and performing operations with fractions. Rewriting fractions with a common denominator, addition, and subtraction are restricted to appropriate cases, including those in which one denominator is divisible by the other (Ministry of Education and Training, 2018). These requirements provide the basis for defining the scope of tasks in this study.

When recognizing a fraction from a diagram, students need to identify the total number of equal parts and the number of parts being considered. When simplifying fractions, they need to ensure that transformations are applied to both the numerator and the denominator. When adding two fractions with unlike denominators, students need to examine the denominators before selecting the calculation steps. These relationships enable teachers to ask students to state the order of steps and explain why each operation is necessary. Conceptual understanding and procedural skill can support each other in mathematics learning (Rittle-Johnson et al., 2001). From this perspective, developing algorithmic thinking through fraction instruction needs to involve asking students to explain the mathematical basis of each step and understand the conditions under which a procedure applies. Scratch, with its block-based programming environment, provides an additional means of representing and testing sequences of steps (Resnick et al., 2009). In this study, the tool was used in selected appropriate activities after students had determined a solution approach using their mathematical knowledge.

3. METHODS

3.1 Research design and participants

The study employed an instructional experiment involving two intact classes and combined quantitative and qualitative assessment. The experiment was conducted at Minh Tien Primary and Lower Secondary School, Lang Son Province, during instruction on Fractions and Operations with Fractions in the second semester of the 2024–2025 school year. Class 4A1, with 32 students, was the experimental class; Class 4A2, with 30 students, was the control class. The groups were not formed through random assignment.

The two classes used the same textbook series and followed the same content, instructional time allocation, and expected learning outcomes. Each class was taught by a different teacher. Before the experiment, the researcher discussed the content and assessment procedures with the teachers. The experimental-class teacher received lesson plans, worksheets, Scratch projects, and guidance on their use; the control-class teacher followed the school's usual teaching plan. End-of-first-semester mathematics test scores were used as the pre-test to examine students' baseline attainment.

3.2 Content and implementation of the experiment

The strategies were implemented throughout the topic, covering the recognition of fractions, their basic property, simplification, rewriting fractions with a common denominator, comparison, operations, and related problem solving. The teacher selected procedures according to the purpose of each activity, with the shared requirement of providing opportunities for students to analyze, articulate, execute, and check their procedures. Table 1 summarizes the three strategies.

Table 1. Intervention content and key learning activities

Strategy	Main instructional approach	Student activities
Exploration and development of new knowledge	Use situations, images, and models; ask questions to help students identify operations; support the formalization of mathematical knowledge	Observe, break the task down into specific actions, organize and carry them out; compare results with the model
Organization of mathematical problem-solving activities	Guide analysis of the given information and task requirements; discuss solution approaches, carry them out, check, and apply them	State the sequence of solution steps, explain the choice of operations, present solutions, and correct steps that are not appropriate
Use of Scratch to support learning	Prepare projects and blocks; organize block sequencing, test runs, and comparison with paper-based procedures	Link mathematical steps to blocks, identify errors, make corrections, and rerun the program; test with similar data

For example, in an activity introducing the concept of a fraction, students observe a cake divided into eight equal parts, with one part removed. The teacher asks them to identify the information needed and how to represent the part removed. Students identify the actions required: count the total number of equal parts, count the number of parts removed, and find a notation that represents both pieces of information. The teacher introduces fraction notation and the terms numerator and denominator; students compare the notation with the image. They then apply the procedure to a circle divided into six equal parts, with the number of shaded parts varying. This example illustrates how activities are organized within the set of lessons, clarifying the combination of student exploration and the teacher's introduction of mathematical conventions.

In activities involving Scratch, the teacher prepares appropriate blocks for students to arrange and check. The content focuses on simplifying fractions in simple cases and adding fractions within the scope of the Grade 4 curriculum. Students determine the procedure on paper before using the software, then compare and explain the results. The use of the tool is adjusted to the available instructional time and classroom equipment.

3.3 Instruments and data collection

The quantitative data comprised pre-test scores supplied by the school and post-test scores from both classes. The post-test was administered under the same conditions, lasted 40 minutes, and was scored using the same marking guidelines. It comprised three multiple-choice questions worth a total of 3 points and two constructed-response questions worth a total of 7 points. The content focused on the meanings of the numerator and denominator, selecting steps for fraction addition, identifying errors, representing fractions in contextual situations, and solving a fraction-addition problem that required students to present their procedure.

The results were analyzed on a 10-point scale using four score bands: below 5, 5–7, 8, and 9–10. These bands were used to describe score distributions in the study. The timing and data sources of the pre-test and post-test were clearly specified: first-semester scores reflected students' prior attainment in mathematics, whereas the post-test focused on the fraction content taught during the experiment.

The qualitative data included records from observations of selected lessons, examples of student work and completed worksheets, and comments from discussions with students and the experimental-class teacher. The analysis focused on the five specified manifestations of algorithmic thinking. Students in the cases are identified by initials. Individual accounts were used to illustrate approaches to tasks; determining how prevalent these manifestations are requires a broader dataset.

3.4 Data analysis

Frequencies, percentages, mean scores, and post-test standard deviations were used to describe and compare the two classes. Percentages were calculated from the number of students in each score band; sample standard deviations were calculated from the post-test score distributions. The difference between the mean post-test and pre-test scores was presented as a descriptive indicator, taking into account the differences in the content coverage of the two tests.

The qualitative material was organized into three categories: task analysis and construction of a sequence; execution, checking, and error correction; and reflection and application. These categories encompass the five manifestations and allow the relationships among the activities to be examined. The analysis distinguished between descriptions of students' actions, participants' accounts, and the researcher's interpretations. Conclusions were limited to the evidence available within the scope of the experiment.

4. RESULTS

4.1 Learning outcomes before and after the experiment

The mean pre-test score was 7.31 for the experimental class and 7.37 for the control class. Neither class had any students scoring below 5. The numbers of students scoring 8 or above were 13/32 (40.6%) and 13/30 (43.3%), respectively. These indicators suggest that initial mathematics attainment was relatively similar in the two classes, providing a reference point for examining the post-test results.

Table 2. Mean scores before and after the experiment

Group	Number of students	Pre-test	Post-test	Post-test deviation standard	Change
Experimental 4A1	32	7.31	8.28	1.42	+0.97
Control 4A2	30	7.37	7.40	1.50	+0.03

Note: The pre-test comprised end-of-first-semester test scores; the post-test was the same test administered to both classes after the experiment. Change was calculated from the rounded mean scores and is descriptive.

After the experiment, the experimental class had a total score of 265, corresponding to a mean of 8.28; the control class had a total score of 222, corresponding to a mean of 7.40. The difference in mean post-test scores was approximately 0.88 points. The standard deviations were 1.42 and 1.50, respectively, indicating relatively similar score dispersion. Table 3 presents the score distributions at both time points.

Table 3. Test score distributions before and after the experiment

Score band	EG pre-test	CG pre-test	EG post-test	CG post-test
Below 5	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (3.3%)
5–7	19 (59.4%)	17 (56.7%)	9 (28.1%)	15 (50.0%)
8	5 (15.6%)	6 (20.0%)	8 (25.0%)	7 (23.3%)
9–10	8 (25.0%)	7 (23.3%)	15 (46.9%)	7 (23.3%)
Total students	32	30	32	30

Note: EG = experimental group; CG = control group. Each cell gives the number of students and the corresponding percentage. Percentage totals may deviate by 0.1 percentage points because of rounding.

At post-test, 23/32 students in the experimental class scored 8 or above (71.9%), approximately 25.2 percentage points higher than the proportion of 14/30 (46.7%) in the control class. In the 9–10 score band, there were 15 students in the experimental class (46.9%) and 7 in the control class (23.3%). No students in the experimental class scored below 5, whereas one student in the control class did. These results indicate a score advantage for the experimental class on the test taken by both classes.

Compared with the pre-test, the mean score increased by 0.97 points in the experimental class and 0.03 points in the control class. The numbers of students scoring 8 or above increased from 13 to 23 and from 13 to 14, respectively. These changes provide additional descriptive information about students' learning. As the two tests differed in content coverage, interpretation should focus on the post-test taken by both classes and incorporate evidence of the learning process.

4.2 Manifestations of algorithmic thinking through learning activities and student work

Task analysis and the construction and articulation of sequences of steps. Records from the experimental class indicate that students were engaged in discussions of the given information, task requirements, and actions needed before carrying out calculations. In the group activities described, students expressed their solution approaches verbally or through diagrams, thereby clarifying the sequence of actions. This provides evidence of their ability to articulate procedures alongside the final results.

The case of N.V.A illustrates this direction of change. According to the recorded account, the student had previously tended to add both the numerators and the denominators when adding fractions. After participating in the activities, the student reported paying attention to the denominators, noting the actions needed on scrap paper, and then finding a common denominator, rewriting the fractions with that denominator, and adding. The account suggests that the student recognized the need to consider the conditions before applying a rule. However, as this is a single student's self-report, its main value is to illustrate how the student perceived their own procedure.

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Articulating sequences of steps also helps teachers identify gaps in students' understanding. When students state only the calculation, teachers may find it difficult to determine whether they have considered the relationship between the denominators. When students articulate the steps, the link between identifying the task and selecting operations becomes clearer. This is a pedagogical implication that can be drawn from the documented cases and requires further investigation across a wider range of student work.

Executing sequences of steps, checking, and correcting errors. Paper-based and Scratch activities provided opportunities for students to compare their results with the established sequence. The case of T.H.M, documented during a fraction-simplification activity in Scratch, indicates that the group noticed an incorrect result, inspected the blocks, and identified a misplaced block for dividing the numerator. According to the student's account, the group repositioned the block, reran the program, and obtained the correct result.

This case illustrates the connection between execution and checking: students used the output of a test run to reconsider how they had represented the sequence. Mathematically, the issue to examine is whether the transformations of the numerator and denominator were performed correctly. Correcting blocks contributes to the development of algorithmic thinking only when students can relate the software error to the corresponding mathematical step. The available evidence suggests that students can participate in error correction, but does not establish the proportion who can perform this activity independently.

Reflecting on procedures and applying them to similar tasks. The summary of post-experiment observations records initial instances of students applying learned procedures to similar tasks. This manifestation needs to be considered alongside their ability to restate a sequence and explain it when the given information changes. In the activity design, the teacher created opportunities for application by changing the fractions or numerical values after students had carried out and checked one case.

Compared with the preceding two categories of manifestations, the evidence for reflection and application currently consists mainly of summarized observations and does not fully describe each student's level of independence. These results are therefore considered preliminary indications. Establishing whether students can apply procedures consistently requires further observation of new tasks and the levels of support they use.

The experimental-class teacher's comments provide an additional perspective on implementation conditions. The teacher noted that prepared lesson plans and Scratch projects supported the organization of activities and created opportunities for students to explain their steps. The teacher also emphasized the need to keep Scratch in a supporting role and to prepare blocks in advance to stay within the available instructional time. This observation suggests that feasibility is linked to the preparation of learning materials and the selection of appropriate tasks.

5. DISCUSSION

The quantitative results indicate that the experimental class achieved a higher mean score and a greater proportion of high scores on the post-test taken by both classes. The qualitative records offer a plausible explanation: students were asked to clarify tasks, articulate sequences of steps, and check their procedures during learning. These activities may support the recognition of the conditions under which rules apply and the identification of errors. However, the available data do not establish the separate contribution of each activity to test scores.

When comparing these findings with fraction research, it is necessary to distinguish computational performance from the understanding demonstrated in explanations. Moss and Case (1999) reported an advantage in rational-number understanding for the group taught using their experimental curriculum, while finding no difference in conventional computation. Although the scope and design of that study differ from those of the present study, its findings highlight the need to consider test scores alongside how students think. In this paper, qualitative evidence helps identify some manifestations that total test scores do not fully capture.

The role of technology also needs to be interpreted in relation to mathematical activity. Scratch's use of programming blocks enables learners to represent and test ideas (Resnick et al., 2009). In the experiment, the tool supported the observation of sequences and the examination of errors. The value of an activity depends on students' ability to explain the relationship between mathematical steps and blocks. This view is consistent in some respects with the ScratchMaths study by Benton et al. (2017), in which teachers played a role in clarifying the connections between programming activities and mathematical knowledge. Engaging students in predicting results, explaining sequences of steps, and identifying errors offers guidance for using Scratch to support fraction learning. As all three strategies were implemented concurrently, the study reports only the outcomes of the combined intervention.

For teaching practice, the findings suggest that teachers should select tasks in which students can clearly articulate what needs to be done and have appropriate means of checking their work. Questions about why a step is performed, its position in the sequence, and the basis for evaluating a result should be tied to specific task requirements. Visual learning materials, worksheets for recording steps, or Scratch projects should support students in carrying out these activities. The level of teacher support should be adjusted to students' abilities, particularly when asking them to check their work independently and apply procedures.

The study has several limitations that need to be considered. Each condition included only one class taught by one teacher, so the influence of the strategies is intertwined with class and teacher characteristics. The pre-test consisted of first-semester scores and differed in scope from the post-test. The post-test covered only selected fraction content; the qualitative data focused on the

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experimental class and illustrative cases and do not permit comparisons of changes in each manifestation between the two classes. Future studies should include more classes, describe the observation tasks more explicitly, and collect student work from both groups to strengthen the conclusions.

6. CONCLUSION

The experiment involving two Grade 4 classes showed that the class taught fractions through an approach aimed at developing algorithmic thinking achieved better post-test results than the control class. The qualitative evidence documented students' ability to identify what needed to be done, organize sequences of steps, check their work, and participate in error correction; manifestations of reflection and application were documented at a preliminary level. The findings suggest that combining knowledge exploration, mathematical problem solving, and supporting tools may create further opportunities for students to articulate and regulate their task-solving processes. In applying these strategies, teachers need to adhere to the requirements for Grade 4 fraction content, prepare learning materials, and select appropriate levels of support. Within the scope of two classes, the study provides an initial basis for further refinement of the strategies and their examination in a wider range of teaching contexts.

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