EFFECTIVE METHODS FOR DEVELOPING PROBLEM-SOLVING SKILLS IN PRIMARY SCHOOL STUDENTS

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Abstract. This article examines how primary school teachers can build durable problem-solving skills in young learners during mathematics lessons. Word problems are treated not as a narrow arithmetic exercise but as a tool for developing logical reasoning, mathematical language, and independent thinking. The paper reviews the theoretical foundations of problem-solving instruction, describes a set of methods that have shown practical value in the primary classroom — staged problem analysis, visual and schematic modelling, the bar model, problem transformation, student-generated problems, collaborative learning, and game-based tasks — and outlines how these methods can be combined into a coherent lesson sequence. Particular attention is paid to the gradual shift from teacher-guided analysis to independent work and to the role of reflection after a solution has been found.

Keywords: primary education, mathematics, word problems, problem-solving skills, modelling, bar model, metacognition, collaborative learning.

1. Introduction

Learning to solve word problems is one of the most demanding tasks a child meets in the first years of school. A word problem asks the learner to read a short story, recognise the quantities hidden in it, understand how these quantities relate to one another, choose an arithmetic operation, carry it out, and finally check whether the answer makes sense in the original situation. Each of these steps draws on a different ability, and a weakness in any one of them can prevent the child from reaching a correct result even when computational skills are sound.

For this reason, problem solving occupies a central place in modern primary mathematics curricula. It is the area where arithmetic knowledge meets real life and where children first learn that mathematics is a way of thinking rather than a collection of rules to be memorised. At the same time, classroom experience shows that many pupils approach word problems mechanically: they pick out the numbers, guess an operation from a familiar keyword such as "altogether" or "left", and write down an answer without considering whether it is reasonable.

The purpose of this article is to describe methods that help teachers move pupils away from such mechanical behaviour and towards conscious, reasoned problem solving. The discussion is based on an analysis of pedagogical and psychological literature and on generalised observations of mathematics teaching in the primary grades.

2. Theoretical background

The modern understanding of problem solving owes a great deal to George Pólya, who described the process as four connected stages: understanding the problem, devising a plan, carrying out the plan, and looking back [1]. Although his model was formulated for older students, it translates naturally to the primary classroom, where each stage can be turned into a routine supported by simple questions from the teacher. The stage of looking back is particularly important and, in practice, the one most often omitted.

A second foundation comes from developmental psychology. According to L. S. Vygotsky, a child can accomplish with the help of an adult or a more capable peer tasks that lie beyond what he or she can do alone; this area is known as the zone of proximal development [2]. Applied to word problems, the

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idea suggests that support should be generous at first and then withdrawn step by step, so that external guidance gradually becomes the pupil's own internal plan of action. J. Bruner's sequence of enactive, iconic, and symbolic representation [3] complements this view: young learners understand a relationship more easily when they first act it out with objects, then draw it, and only afterwards express it with numbers and signs.

Research on mathematical proficiency also emphasises that problem solving is not a separate topic but one strand of a broader competence that includes conceptual understanding, procedural fluency, adaptive reasoning, and a productive disposition towards mathematics [4]. A. Schoenfeld further showed that success depends not only on knowledge but also on metacognitive control — the ability to monitor one's own progress and change direction when a chosen approach is not working [5]. Together, these ideas indicate that effective instruction must address understanding, representation, strategy, and self-regulation at the same time.

3. Effective methods of instruction

Experience in the primary classroom suggests that no single technique is sufficient on its own. The methods described below work best as a system in which each one strengthens a particular stage of the solution process.

Staged analysis of the problem. Before any calculation, pupils are taught to work through the text with a fixed set of guiding questions: What is the problem about? What do we know? What must we find? Which of the given facts will help us? Reading the problem aloud, retelling it in one's own words, and separating the condition from the question turn a dense text into a clear structure. Over time, the teacher's questions become a checklist that pupils use without prompting.

Visual and schematic modelling. Drawings, diagrams, short notes, and tables allow children to see relationships that are difficult to hold in mind as words. A problem about two boxes of pencils, for instance, becomes far more transparent when the boxes are drawn as segments of different lengths. The model shifts attention from isolated numbers to the structure of the situation, which is exactly what the choice of operation depends on.

The bar model. This method, widely used in Singapore mathematics, represents known and unknown quantities as rectangular bars whose lengths can be compared, joined, or divided [6]. Its strength lies in its universality: the same drawing technique serves for addition and subtraction problems, comparison problems, and later for problems involving fractions and ratio. Because the bar model is introduced through concrete objects and then simplified into a sketch, it follows the enactive–iconic–symbolic path described by Bruner.

Teaching problem types and schemas. Pupils make better progress when they learn to recognise the underlying type of a problem — combining parts into a whole, change over time, or comparison of two quantities — instead of relying on surface keywords. Studies of schema-based instruction have shown that explicitly teaching such categories, and showing how a new problem can be linked to a familiar schema, improves both accuracy and transfer to unfamiliar tasks [7; 8].

Transformation of problems. Once a problem has been solved, the class can change it: replace the numbers, swap the condition and the question, add or remove a piece of data, or turn a simple problem into a compound one. Pupils observe how each change affects the solution, which deepens their understanding of the relationships involved and discourages memorisation of ready-made patterns.

Problems composed by pupils. Writing one's own problem from a picture, a diagram, a numerical expression, or an everyday situation reverses the usual direction of work. To compose a sensible problem,

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the child must think about what information is needed and how the question follows from it. Such tasks also raise motivation, because pupils enjoy solving problems written by their classmates.

Collaborative learning. Work in pairs and small groups gives every child the opportunity to explain a solution, listen to an alternative, and defend a choice with arguments. Discussing several ways of solving the same problem shows that mathematics allows different routes to a correct result and helps weaker pupils learn from the reasoning of their peers, in line with the idea of the zone of proximal development.

Didactic games and real-life contexts. Problems built around shopping, travel, school events, or sports, as well as short competitive games and puzzles, make mathematical content meaningful to young learners. Such tasks are particularly valuable at the beginning or end of a lesson, when they refresh attention and show pupils why the skills they are learning are useful.

Reflection and self-checking. The final stage of every solution should include checking the answer by a reverse operation, estimating whether the result is realistic, and briefly discussing what helped to find the solution. These habits develop the metacognitive control that Schoenfeld identified as a key factor in successful problem solving [5].

Table 1 summarises how each method relates to the stages of the solution process.

Table 1. Methods of developing problem-solving skills and their main purpose

Method	Stage of the solution process	Main purpose
Staged analysis	Understanding the problem	Separating the condition from the question; identifying known and unknown data
Schematic modelling	Understanding and planning	Making relationships between quantities visible
Bar model	Planning	Choosing the operation from the structure of the problem
Problem types and schemas	Planning	Linking a new problem to a familiar structure; supporting transfer
Transformation of problems	Looking back	Showing how changes in data affect the solution
Problems composed by pupils	All stages	Developing understanding of problem structure and motivation
Collaborative learning	All stages	Explaining, comparing, and justifying solutions
Games and real-life contexts	Understanding the problem	Increasing interest and the meaningfulness of tasks
Reflection and self-checking	Looking back	Checking the answer and developing self-control

4. Practical recommendations for teachers

Introducing the methods described above requires careful planning. First, the teacher should keep the same sequence of steps — reading, analysis, modelling, solution, checking — in every lesson until pupils follow it on their own. Consistency is more important than variety at the early stage, because a stable routine frees the child's attention for the content of the problem.

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Second, support should be reduced gradually. In the first grade, the teacher may lead the whole analysis through questions and draw the diagram on the board; in the second grade, pupils complete partially prepared diagrams; by the third and fourth grades, they are expected to choose and build a model independently. This progression reflects the principle of moving from joint to independent activity.

Third, tasks should be differentiated. Pupils who struggle benefit from problems with a ready-made diagram or a set of hint cards, while more confident learners can be given problems with missing or excessive data, open questions that allow several answers, or the task of finding more than one solution. Such differentiation keeps the whole class engaged without lowering expectations.

Finally, assessment should value the reasoning as well as the answer. Asking pupils to explain how they reached a result, or to compare two solutions, gives the teacher insight into their thinking and signals to children that the path to the answer matters.

5. Conclusion

Developing problem-solving skills in the primary grades is a long-term process that cannot be reduced to repeated practice of standard tasks. The analysis presented here shows that the most productive approach combines staged analysis of the text, visual modelling — including the bar model — explicit attention to problem types, creative work with problems, collaboration among pupils, and systematic reflection. When these methods are used together and support is withdrawn step by step, children learn not only to find correct answers but also to understand problem situations, to plan their actions, and to evaluate their own results. These abilities form a foundation for success in later mathematics and in other school subjects that demand logical thinking.

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