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TYPOLOGY OF INTEGRATIVE MATHEMATICAL TASKS AND THE TECHNOLOGY OF THEIR DESIGN

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Abstract. The article develops a typology of integrative tasks in mathematics education and proposes a technology for designing them. Tasks are classified by direction of integration, level of integration and cognitive demand. A six-stage technology for designing an integrative task and criteria for checking task quality are substantiated.

Keywords: integrative task, typology, design, cognitive level, Bloom's taxonomy, mathematics.

Introduction. In mathematics education, the basic unit of student activity is the task (a problem or an exercise). The kinds of tasks students work with shape their mathematical thinking. Therefore, the decisive condition for implementing an integrative approach is a system of high-quality integrative tasks. However, most "applied" problems in textbooks belong to another subject only in appearance, and solving them does not require knowledge of that subject. For example, the problem "A train travelled 240 km in 3 hours; find its speed" has a physics context but is not integrative.

The aim of the article is to develop a typology of integrative mathematical tasks and to propose a technology for designing them.

Research methods. The study used theoretical analysis, content analysis of tasks in school textbooks, classification and pedagogical design methods.

Literature review. The classification and design of learning tasks has a long history in didactics. V.P.Bespalko developed a system of tasks corresponding to levels of mastery[1], and L.Anderson and D.Krathwohl developed a taxonomy of cognitive processes[2]. The theory of integrative tasks draws on the work of R.Fogarty[3] and V.N.Maksimova[4] on interdisciplinary connections. M.Niss and W.Blum[5] gave recommendations on designing modelling tasks, and J.Boaler[6] on open tasks. PISA tasks are an example of tasks constructed along the dimensions of context, content and process[7]. However, distinguishing integrative mathematical tasks by the criterion of necessity and a technology for designing them have not been addressed in the national literature.

Results and discussion. The concept of an integrative task. An integrative task is understood as a task whose solution requires the joint application of knowledge from mathematics and at least one other subject and whose result can be meaningfully interpreted from the standpoint of both

subjects. An important feature of this definition is necessity: if the task can be solved without knowledge of the other subject, it is not integrative but merely a contextual task.

Typology. It is proposed to classify tasks according to three criteria. By direction of integration: intra-subject (algebra and geometry), two-subject (mathematics and physics) and multi-subject (project) tasks. By level of integration: contextual (the other subject serves only as a setting), connecting (knowledge of the other subject is part of the solution) and synthetic (knowledge from the subjects leads to new understanding). By cognitive demand – according to the taxonomy of L.Anderson and D.Krathwohl: remembering and understanding, applying, analysing, evaluating and creating[2]. The intersection of the three criteria makes it possible to design tasks systematically (Table 1).

Table 1.

Level	**Description**	**Example (mathematics + geography)**
Contextual	The other subject serves only as a setting	The map scale is 1:100,000. How many km are 5 cm?
Connecting	Knowledge of the other subject is part of the solution	Calculating the distance along a meridian from the coordinates of two cities
Synthetic	Leads to new understanding	Building a growth model from a population table and making a forecast for 2030

Table 1. Sample tasks by level of integration

As V.V.Davydov emphasized, theoretical thinking develops in students not by multiplying empirical examples but through tasks that reveal the essence of a concept[8]. From this point of view, synthetic-level tasks are the most valuable part of integrative education, but they should be introduced step by step on the basis of contextual and connecting tasks.

Design technology. An integrative task is designed in six stages: (1) defining the mathematical goal – which mathematical concept or method the task develops; (2) finding the point of integration – in which subject this concept is naturally applied; (3) selecting a real context – authentic data and situation; (4) building a chain of questions – from a contextual question to a synthetic one; (5) checking the solution and interpretation – agreeing on the accuracy of the context with the teacher of the other subject; (6) defining assessment criteria – separate criteria for mathematical correctness and contextual interpretation.

Quality criteria. A designed task is checked against the following criteria: alignment of the mathematical content with curriculum requirements[9]; necessity of knowledge from the other subject; authenticity of the context and its suitability for the students' age; a clearly defined cognitive demand; interpretation of the result from the standpoint of both subjects. As S.Brookhart emphasized, criteria for assessing complex tasks should be defined in advance and known to students[10].

The discussion shows that designing integrative tasks requires the teacher to have knowledge of both mathematics and the other subject, as well as methodological creativity. It is therefore advisable to develop such tasks collectively within subject methodological associations and to collect them in the form of a "task bank". Uzbek pedagogy has also emphasized the need for a systematic approach to designing learning tasks within innovative educational technologies[11].

It is advisable to use digital technologies when creating a bank of integrative tasks. If tasks are stored in a spreadsheet or database tagged by mathematical topic, direction and level of integration, and cognitive demand, a teacher can quickly find the right task for a lesson. In addition, if comments from teachers who have tried a task (what difficulties arose, what support was needed) are added to the bank, it becomes richer in quality over time. Such collaborative methodological work is also consistent with NCTM recommendations[12].

Conclusion. An integrative mathematical task is a task whose solution necessarily requires the joint application of knowledge from mathematics and another subject. Tasks were classified by direction of integration, level of integration (contextual, connecting, synthetic) and cognitive demand. A six-stage technology for designing an integrative task and five quality criteria were proposed. These results serve as a methodological basis for mathematics teachers in creating a bank of integrative tasks.

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