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Olympiads without Words

Pavel S. PANKOV, Elzat J. BAYALIEVA
Institute of Mathematics, Kyrgyzstan
J.Balasagyn National University, Kyrgyzstan
e-mail: pps5050@mail.ru, elzat.bayalieva@gmail.com

Abstract. To involve as many children as possible from an earlier age in the Olympiad movement, tasks without any conventional signs and denotations are proposed (these tasks can be called “natural”). Drag-and-Drop technique is used for this purpose, with varieties: ”n-to-1” (selecting an object to be dragged to the spot); ”1-to-m” (selecting the spot or a place the object to be dragged to); ”n-to-m” (selecting both an object or a collection of objects and the spot(s) to be dragged to). Parametrizing is necessary: when restarting the program, a slightly different task is to be generated. A sequence of these tasks (in learning mode for any definite language: with announcements after successful completion: “Congratulations, you have mastered the notion of…”) would also be an unobtrusive training course for children. These tasks can be also used for checking and improving AI.

Keywords: Olympiad, children, parametrized task, common sense, guessing, Drag-and-Drop.

1. Introduction

At all times, while learning the essence of any subject one also has to learn the system of symbols (notations) and special terms traditionally used in it. This causes the following disadvantages:

- Pupils and even some teachers confuse the content of a subject with its form, they do not recognize real life applications of its items and cannot apply their skills and knowledge.
- Many persons of good ability and poor initial knowledge are frightened of such a system and do not try to learn at all.
- If the state (official) language of teaching or symbols used are well known by many pupils, then those pupils have a great advantage over those unfamiliar.

Therefore, summarizing teachers’ attempts to make teaching more intelligible and visual, we suggested developing of *independent learning* (Pankov, 1996): ways of teaching and assessment which make minimal use of any media system not related to the content of the subject.

We also proposed to compose Olympiad tasks with minimal use of additional conditions and restrictions (Pankov, 2008), to increase the use of *common sense* by Socrates' method in learning mathematics (Pankov *et al.*, 2015).

In this paper we propose to use this method for expanding the age range for children involved in the Olympiad movement. The problems are designed in such a way that no mathematical knowledge is required to understand and to enter the answer surely. Certainly, each task is to be tested before including to the set of tasks of the Olympiad.

Also, this paper continues the question put in Pankov *et al.* (2023): What mathematical and other topics are present latently in *common sense*?

Sections 2 and 3 contain definitions and classification of objects of Drag-and-Drop technique: Target, Spot and Movable objects, requirements to parametrize tasks.

Sections 4, 5, 6 and 7 consider various types of tasks without words: on similarity; on relations; on equalization; on forecasting.

Remark. Some issues in this article cannot be covered by any general definitions or explanations. They can be demonstrated by examples only.

Remark. Certainly, there are a lot of publications and software touching on this topic and we cannot claim originality for each item. However, many of such publications contain general advice and recommendations only.

For example, a recent work (Hatisaru, 2020), which has, in turn, a vast list of 89 references including 7 ones by the author. But all tasks are in standard form:

Can you solve $7x + 4 = 5x + 8$?

On squared paper, draw as many different parallelograms as you can with an area of 12 square units.

[Here is a mistake: there are infinitely many such parallelograms: (0; 0)-(n; 1)-(n + 12; 1)-(12; 0)].

And a suggestion to the teacher: *Giving students cards depicting the same mathematical idea or concept (e.g., polyhedron) in different ways (e.g., verbal, visual, pictorial descriptions) and asking them to match the cards to enable them to draw links between the different representations of the same concept and to develop new mental images for it.*

Remark. There is a widespread genre: pictures and series of pictures "without words". This paper may be considered as an "invitation to act" after observing such pictures.

2. Definitions and Classification

Although we try to avoid any conventions, nevertheless some are necessary and will be involved latently.

The Spot (to drag Movable objects to it) will be in the middle of the screen and will be denoted by any color (light green) which will not be used anywhere else.

A Movable object of any color has an outline of the same dark color.

Movable objects to be dragged will be in the lower part of the screen and Targets will be in the upper part.

First tasks will be evident and the user will unconsciously master these conventions.

Varieties for Drag-and-Drop technique:
”n-to-1”: there are several Movable objects and one Target near the Spot. The user is to choose and to move one of Movable objects to the Spot;
”1-to-m”: (without a separate Spot): there are one Movable object and several Targets. The user is to choose and to drag the Movable object to any place (neighbor) of Targets;
”n-to-m”: there are several Movable objects and several Targets. Such complex task is given if the user has passed previous similar tasks successfully. The user is to drag some Movable objects, the announcement (congratulation) appears after all implied Movable objects are dragged to correct Targets.

Movable objects may be

- Solid; only parallel shift is possible by the custom.
- Rotatable (for instance, a segment).
- Transformable (for instance, a chain).

(Rotatable and Transformable objects may be marked by a little circle of dark color at the edge; it is also a clue for the user).

We consider only solid Movable objects in the paper; the only example of Rotatable object is in Task 9.

Remark. Of course, Rotatable and Transformable objects and more difficult for programming and can generate a wide variety of tasks, the proposed method is not limited.

We propose tasks to guess which may be classified as, *searching analogs* (similarity); *using relations* (as often used in IQ tests); *equalization on scales* (visualization of solving linear equations for children); *forecasting* (the simplest example is “continue the sequence …”). At the same time, it is known that many human ideas cannot be expressed in words (in instructions, descriptions). The simplest example is music.

We hope that some of these tasks proposed by us or invented by others in the framework of the proposed method would cover new ideas which cannot be classified in any verbal form.

3. Requirements

Tasks must be parametrized: when restarting the program, a slightly different task (with the same level of difficulty) is to be generated randomly.

This provides all contestants with different tasks and prevents mutual hints. Also, if the software is used for learning, restarting it yields different tasks that makes learning to be more interesting.

Tasks must be “culturally neutral”.

After successful completion of the task, a nice piece of music and an incentive badge (not a smiley because smileys have definite colors) must be played to the user.

If the software is intended for learning in different languages then after a successful completion of the task an announcement appears:

Congratulations, you have mastered the notion of ...
in the chosen language.

4. Introduction, Examples of Tasks on Similarity

Only the number of the task and drawings (figures, objects) are shown to the user (child). Themes of tasks, words “Target”, “Movable object” below are for programmers and teachers.

Certainly, tasks would be more interesting for children in a colorful, geometric form. Examples are given below in pseudo-graphic for brevity. The Spot is denoted as (?).

(Optional, for younger children; an adult may help)

Task 0. Introduction (1-to-1): The Spot, the Movable object. If the user does nothing then the Movable object moves to the Spot and returns.

Task 1. Colors (n-to-1). The Spot, the Target as a yellow square near (over) the Spot, Movable objects as equal circles of different colors, one of them is yellow.

(After restarting: a blue circle; equal triangles of different colors, one of them is blue, etc.)

This is a particular case of

General Task 2. Property-choose (n-to-1). The Spot, the Target as an image with any Property, Movable objects as similar images (but different from the Target) of different properties, one of them has the same Property.

Particular cases:

Task 3. Notion of natural number (n-to-1).

Example (4-to-1):

Target &&&&& (?)

Four Movable objects: ** **** ***** ***

Task 4. Length (n-to-1). The Spot, the Target as a segment near (over) the Spot, Movable objects as slightly broken lines of sufficiently different lengths, one of them is equal to the length of the Target.

(Congratulations! It is *length.*)

Task 5. Area (n-to-1). The Spot, the Target as a rectangle near (over) the Spot, Movable objects as triangles of sufficiently different areas, one of them is equal to the area of the Target.

(Congratulations! It is *area.*)

Task 6. Symmetry-choose (n-to-1). The Spot, the Target as a symmetrical figure near (over) the Spot, Movable objects as figures, one of them has the same symmetry.

Illustrative example 6-1 (5-to-1): Target: Φ ; Movable objects: N, □, □, Z, E

Illustrative example 6-2 (5-to-1): Target: Z ; Movable objects: □, □, §, E, H

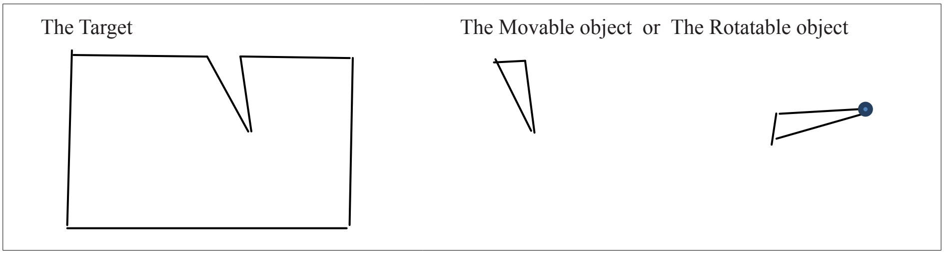
Sub-general Task 7. Linear transformations (n-to-1). The Spot, the Target as a geometrical figure, Movable objects as figures, one of them is a linear transformation of the Target.

Illustrative example (4-to-1):

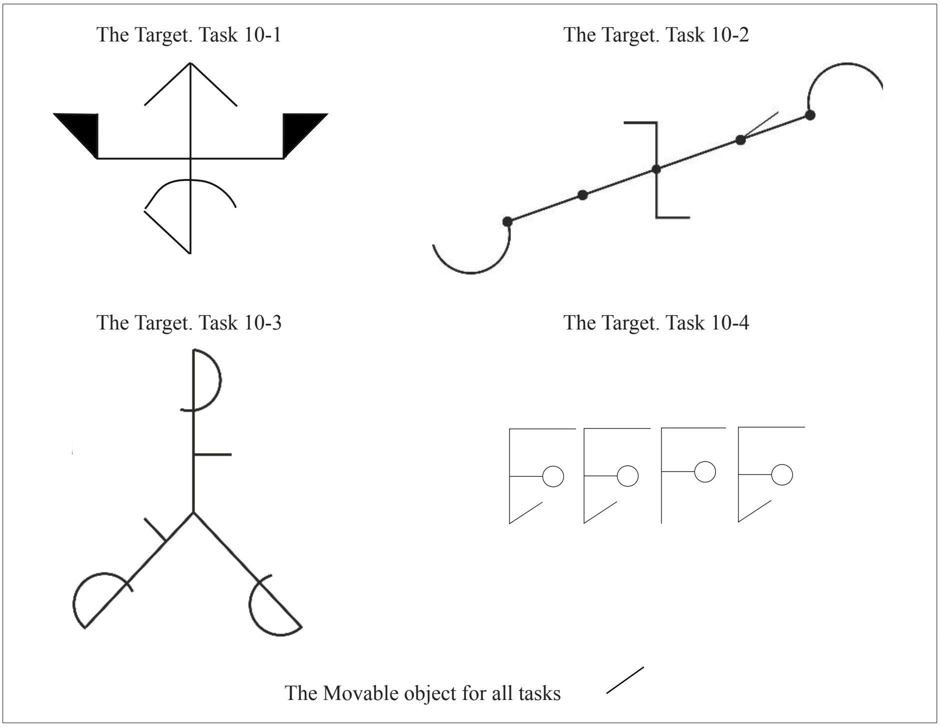
Target: *A* ; Movable objects: Ρ, ∀, ∃, *T*

General Task 8. Property-complete (1-to-m). The Target is a geometrical image “almost with any Property”, the Movable object is a little piece which is to complete the Target.

Task 9. Figure-complete (1-to-m).
Example. The Spot is shown as (light green) neighbor around the Target.



Tasks 10. Symmetries (1-to-m). Four tasks in the following drawing.

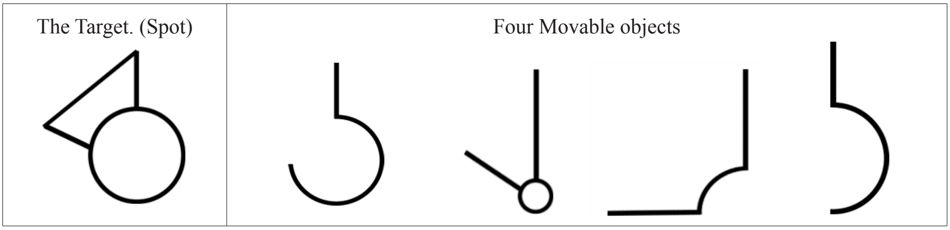


5. Examples of Tasks on Relations

Set operations either on strings or on drawings:

Task 11. Subset (n-to-1).
Example 11-1 (4-to-1):
Target UKDFGE (?)
Four Movable objects: WKD DFG FGZ KSFG

Example 11-2 (4-to-1):



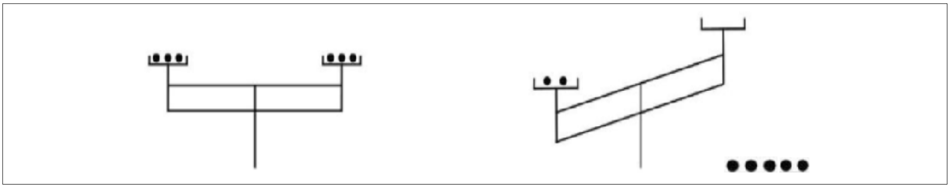
Remark. The radius of the semicircle in the fourth Object is greater than one of the circle in the Target.
By our experience, children note it and choose the first Object surely.

Task 12. Intersection (n-to-1).
Example (5-to-1):
Target UKDFG (?) FDKZPW
Four Movable objects: WKF KUD DGF KFD TDW
Remark. We could not find a suitable way to involve “union of two sets”.

Task 13. New genre? (n-to-n).
Example (3-to-3):
Targets ∪∪∪∪∪∪ ∪∪∪∪∪∪∪∪ ∪∪∪∪∪
(?) (?) (?)
Three Movable objects: **** ***** *******

6. Tasks with Scales (Equalization)

Illustration before the tasks



(the right cup of the right scales is light green)

The following tasks use one set of scales in tilt or two sets of scales: in balance and in tilt and natural numbers as sums of weights on scales. Firstly, the green (right) cup of the scales is up (is lighter in weight than the left one); it is denoted as (>).

Movable objects are (equal) weights.

When the scales become in balance, play affirming beep sounds.

These tasks are of type (n(consequently)-to-1).

Remark. Certainly, “the unary system” used here is suitable only for small natural numbers. But it is our goal: we do not teach the child to count, to calculate, to use digits; we give tasks which can be solved without calculations. By our experience, some children solve such tasks successfully.

One set of scales:

Task 14. Introducing the scales.
Example: (*****) > (?)

Task 15. Addition or solving the equation $a = b + x$.
Example: (******) > (****)(?)

Two sets of scales:

Task 16. Multiplication by 2 or 3.
Example: (Cat (or Apple…)) = (***); (Cat, Cat) > (?)

Task 17. Division by 2 or 3.
Example: (Cat, Cat) = (********); (Cat) > (?)

Task 18. Linear equation.
Example 18-1: (Cat, ***) = (********); (Cat) > (?)
Example 18-2. (Cat,Cat,*) = (*********); (Cat) > (?)

7. Forecasting Tasks

The well-known

General Task 19. Continue sequence (n-to-1). The Target is three or four members of a sequence.
Remark. Due to the purpose of this paper, digits as conventional signs cannot be used.
Example (3-to-1). Target: *** ***** ******* (?)
Three Movable objects: ****** ********* ********

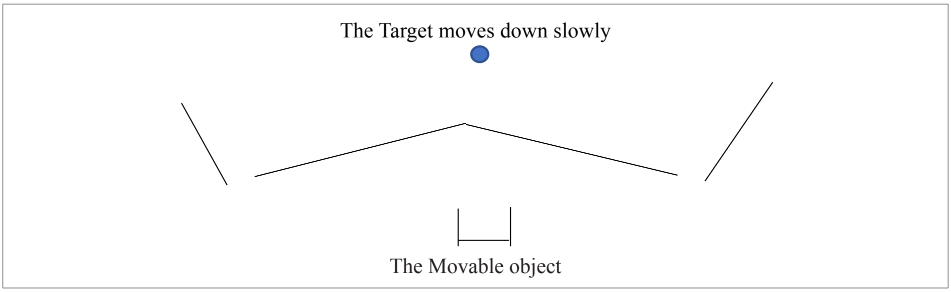
Fast forecasting with corresponding action is a main component of many computer games.

We (Bayachorova *et al.*, 2016) proposed to use slow forecasting for independent presentation of Future Tenses in a language.

We (Pankov *et al.*, 2023) proposed to involve “time” to Olympiad tasks (except the necessary time limit). We did not see such Olympiad tasks.

We propose

General Task 20. Forecasting-action (n-to-1) or (1-to-m). The Target moves slowly. The user is to forecast its further motion and catch it with the Movable object.
The simplest Example (1-to-2).



When the ball touches the roof, there will not be time to shift the box to one of the holes.

8. Conclusion

We hope that this paper will be a source of new tasks for programmers and involve children from an earlier age in the Olympiad movement, promote creation of a new type of software to learn mathematics independently for children in all languages. Also, we hope that these tasks would help to discover new capacities of artificial intelligence. As a consequence of this paper, we can rise the following philosophical problem: what notions or ideas can be expressed without words?

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P.S. Pankov (1950), doctor of physics-mathematics sciences, prof., corr. member of Kyrgyzstani National Academy of Sciences (KR NAS), was the chairman of jury of Bishkek City OIs, 1985–2013, of Republican OIs, 1987–2012, participates in National OIs since 2020, was the leader of Kyrgyzstani teams at IOIs, 2002–2013, 2018–2023. Graduated from the Kyrgyz State University in 1969, is a head of laboratory of Institute of mathematics of KR NAS.

E.J. Bayalieva (1984), Senior Lecturer in the Software Engineering program, Institute of Computer Technologies and Artificial Intelligence, J. Balasagyn National University.