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TYPES OF SOLUTIONS IN THE DIDACTIC GAME "LOGIC MONSTERS"

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Abstract. The article presents the results of the approbation of the game "Logic Monsters". The game is aimed at developing logic thinking and is applicable within various educational subjects. Several different implementations of the game's basic idea have been proposed. Modifications encompass technological performance and cognitive goals directed at both directions of the task. The study covered a core group of students from four countries, aged 14 – 18. A survey, discussion and observation were conducted with them. Additionally, results from a group of teachers and a group of university students with whom discussions and observations were conducted are also presented. Conclusions are obtained and a classification of the types of "solutions" in the different game modifications is presented. A connection is made between the thinking style and the proposed solutions. Several authentic solutions are presented.

Keywords: game; math; training; thinking; active methods; game approaches

1.Introduction

The gamification of learning, or at least the introduction of game elements, has been on the agenda for many years. The problem of proving the effectiveness of games has been addressed since the dawn of their implementation in education (Halverson 2012). Along with the positive attitude and attitudes of students to work with attractive images (Harizanov & Ivanova 2020), there are also questions related to how much time the teacher will have to take from the lesson, how much the game will cost, how much he can maintain discipline when introducing game elements etc.

Khine notes „With the improved design and applications educators will discover effective ways to integrate the games in their teaching" (Khine 2011).

According to Trybus, game learning refers to the application of certain game principles in real life situations for the participants (Trybus 2015).

The other side of the game approach is the possibility of discovering talented students (Grozdev & Doychev 2009). The given article proposes a system of tasks based on game situations, the goal of which is to find a winning strategy. The given tasks are aimed at students with a marked interest in mathematics. The mathematics preparation of talented students in an art school is also specific (Ivanova & Nedelche-

va 2016). The combination of science, mathematics, engineering and the arts has a special place in the preparation of students, regardless of their other interests. This idea is implemented in many schools within the framework of the STEAM approach.

In the opposite direction is the education of bilingual students, and more precisely with that part of them, which shows no interest in education in its classical form and experiences a number of cognitive difficulties. Research shows that even in this group, games have their important place for effective learning (Harizanov & Georgieva 2018).

Many authors examine the didactic capabilities of popular learning platforms. A good example of applying Kahoot is presented in the article „Computer games in mathematics education – challenges and opportunities" (Stoyanova, Dureva-Tuparova & Samardzhiev, 2016).

The question of the application of popular games in education is also being actively studied. An interesting approach to the application of billiards is presented by Chehlarova (Chehlarova 2022). Purely didactic games created by the teachers themselves or by companies working in this direction are also used (Stariradeva 2018).

2. Didactic game "Logic Monsters"

Several games were developed within the "Game based learning for development of problem solving skills" project (Pavlova & Marchev 2021). One of them is the game "Logic Monsters". The game stimulates working with logical constructs and operators in a fun way. The given constructions are particularly important for mathematics and informatics, but they are also used in all other subjects.

Its possibilities have also been studied in the implementation of STEAM training within the project "STEAM in the light of the competence approach".

According to the game duration requirements (Ke, Xie & Xie 2016), the planned duration of each of the mods is about 10 minutes.

3. Cognitive variations of the game

Game scenario

The teacher prepares instruction sheets that describe what a monster should look like. The description uses the logical operators "AND", "OR", "NOT", "excluding OR" ("XOR") and the conditional operator in short "IF ..., THEN ..." and full form "IF ..., THEN …, ELSE …".

Each team/participant chooses a sheet of instructions for what their monster should look like.

Draws a monster according to certain requirements, for example: "Your monster must have 4 legs, 2 arms and 1 eye. Be either green or red. Having a round head or (exclusively or) triangular eyes. If the monster is green, it should have a bow tie, otherwise it should have a triangular hat."

The end of the game is determined by the team/participant that has declared that they are ready. The winner is the team/participant that has fulfilled more requirements and has fewer errors in the resulting pictures.

Game scenario (reversed task):

1. The team describes a task for the opposing team (written form). To do this, he must describe a monster. The teams have a fixed time (5 – 10 minutes) to complete the task (reversed task).
2. Each team draws the task assigned to it.
3. Each team checks the work of the team that drew their monster for mistakes. A discussion ensues.
4. The end of the game is determined by the team/participant that has declared that they are ready. The winner is the team/participant that has fulfilled more requirements and has fewer errors in the resulting pictures.

According to the goals that the teacher has set, it is possible to have a third version of the game:

1. Each team/participant is given a description and picture of a monster.
2. Teams/individual participants must find the mistakes in the picture.
3. The team/participant who first copes with the task and has no mistakes wins.

The game can be played individually or as a team.

In fact, this is the activity from point 3 of the reverse task, but here the teacher can suggest "mistakes", which are particularly strong distractors and are important for students to recognize.

During the testing of the games among teachers, the game was very well received by teachers in different subjects, and interesting modifications to the scenario and examples were suggested while playing the games.

4. Technological variations of the game

Fig. 1 shows an example picture of a "logic monster" realized with the graphical capabilities of Microsoft Word. It is possible to use more attractive templates for bodies, hands, tentacles, horns, etc., which can be arranged using suitable software. They can be printed out and cut out of paper, and students can arrange them, like an appliqué. Modeling with plasticine or other suitable materials is possible.

Another point in the conduct of the game is whether it will be conducted individually or as a team. Each of the cognitive modifications allows for both options.

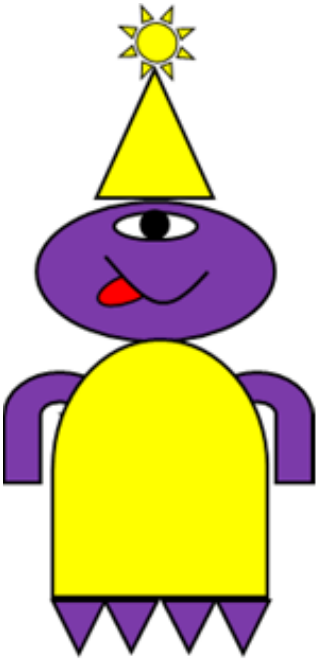

Fig. 1. Logic monster

In the approbation with pupils, teachers and students, we have only used the possibility of drawing with colored felt-tip pens. The variants of the task were mostly performed individually, and the reverse task was performed in teams. Students played both games as a team. This choice was up to the participants in the games, because they were given the opportunity to decide how to play.

The necessary materials, in the various possibilities:

– white sheets and colored pencils/markers (in case the players will draw).

– ready cut templates of heads, eyes, bodies, legs, hats, bow ties, etc.

– ready-made electronic templates of heads, eyes, bodies, legs, hats, bow ties, etc. and appropriate software in which they will be arranged. This can be a graphics editor, a virtual whiteboard, a word processing system, etc.

– plastic or other material convenient for modeling.

– instruction sheets on how the monsters should look.

5. Game approval results

The game was implemented with several groups of participants. One includes 15 students – future mathematics teachers. The other group includes 45 teachers of different subjects. The core group, in which a survey was conducted along with observations and discussion, consisted of 43 students from Poland, Turkey, Romania and Portugal. The students who participated in the study were aged 14 – 18. The game with the students took place at the beginning of 2022 within the framework of a workshop on the "Game based learning for development of problem solving skills" project in the city of Hoyna, Poland.

The technology of the approbation was as follows – moderators in the training explained the rules of the game, then formed teams – in some cases mixed, in some cases the division was by country. Each student had the opportunity to work as an individual player as well, if they wished. After playing the game, students filled out feedback surveys and had the opportunity to discuss the qualities of the game and their experience with it.

In the survey (Pavlova et al. 2022) a Likert scale (1 – 5) was used. Students answered descriptively and two open-ended questions focused on the advantages and disadvantages of the game. Summary data from the first six questions are presented in the diagram in Fig. 2.

As can be seen from the diagram in Fig. 2, the students are united in most of their assessments. They find the game interesting and clear, but they don't find it challenging. This answer surprised us, because within the playing, many discussions and arguments arose in the variant where the students mutually checked the correctness of the images. All disputes ended with the clarification of possible correct executions of a given instruction.

The students' opinion about the difficulty was quite divided. Almost half of the participants find it very easy, and the other half find it very difficult. Several explana-

tions are possible; one is that not all students realized the depth of the game and chose only "light" logic elements to "model" their monsters. The other explanation is that some of the players had very good training in working with logic elements and good deductive logic. This division gave rise to the idea of classifying ways of tackling the game into "light" and "hard". Contrary to our expectations, there were students who tried to make several correct solutions that a given formulation allows. In the description task, however, some very complex constructions were proposed.

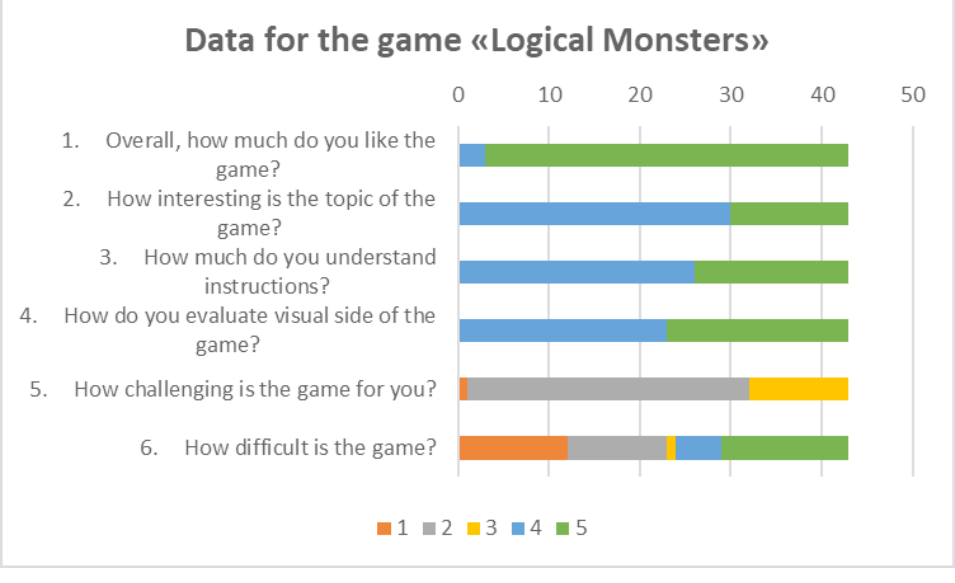

Fig. 2. Survey data for the game "Logic Monsters"

As advantages of the game, students indicate: "Improves creativity, helps develop drawing skills", "Stimulates teamwork, problem-solving skills and the use of imagination", "Very useful and easy to apply. Improves quick thinking", "Helps with the skills of giving clear instructions so people can follow them", "This is really important for lessons, develops logical thinking; it's also fun and funny", "It's a new form of communication, it develops social connections and enables learning in a better way".

As disadvantages, the students point out that: after a few games they get bored; worry that they can't draw well; hard rules; not digital (these students were not given the opportunity to model the monsters digitally).

In the discussions held with the groups of teachers and students, the main opinions came down to the fact that the game is very useful and applicable in teaching

different subjects. The game makes it possible to merge objectives across different subjects, making it easy to incorporate into STEAM scenarios. Options for unification of mathematics and information technology, foreign language and information technology, etc. were discussed. Some teachers have expressed concerns about discipline problems during such games. The game was particularly well received by mathematics, information technology and foreign language teachers. Some of the colleagues modified the rules according to the objectives of their study subject. In contrast to the student and teacher groups, the desire to work as a team prevailed among the students – future teachers, both types of a task. Students and teachers chose individual play for the task and team play for the reverse task.

6. Types of solutions

Many interesting "solutions" were obtained within the framework of the conducted approbation. All participants – students, future and current teachers – were asked to leave their pictures and descriptions after the performances. It was explained that these materials would be used in a pedagogical study. A large part of the participants did not want to leave their products. Their explanation was that they wanted to have a memory of a good experience or that they were worried that they did not draw well. The typification of the "solutions" is based on both the collected material and observational data.

Artistic and creative realization of the task

Here we will not dwell on drawing skills, but more on technology. All participants had a comfortable work area, enough white sheets and felt-tip pens of different colors. The following groups of images formed:

– Single-color/multi-color (in the groups of current and future teachers, pictures in one color predominated, while in the case of students, almost all images were multi-colored);

– Pictures within one sheet/pictures in two or more sheets (unfortunately, none of the participants who realized their image in more than one sheet wanted to submit it for publication). Such images were present in all groups.

– Schematic (with an emphasis on completing the task) / with a creative element.

Logical "complexity" in the direct problem

Here, the participants were divided into two groups – without additions/with additions. Those who tried to complete the task without introducing additional elements that did not contradict the requirements in the task prevailed. About 10% of the participants quite consciously brought "extra" elements into their images and actively entered into a discussion about their "correctness" with the other players. In Fig. 3 several student images are presented, according to a given description, some of which have gaps.

Fig. 3. Pictures of students in a task

Logical "complexity" in the reverse problem

When solving this task, two groups were also formed – complex instructions/ easy instructions. The majority of players mainly used the logical "and" in their descriptions. In some cases, there was also a logical "OR". Nearly 90% of the descriptions were "easy". As "aggravating" factors, players included conditions such as "the monster has 1,000 legs," "has a tail 1 meter long," and so on. The inclusion of such conditions and the subsequent creative handling of them by the opposing team help to form a number of competencies and are important for the learning process.

Pictures created according to the descriptions given by students from the opposing team are shown in Fig. 4.

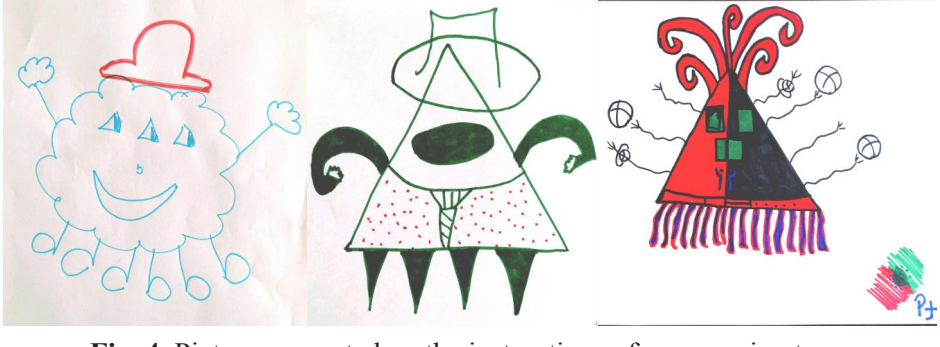

Fig. 4. Pictures executed on the instructions of an opposing team

The teams, given complex structures, handled them very skillfully. They used the full range of possibilities, there were even examples with nested "IF" statements.

It was interesting to see the reaction to an exchange of instructions, where one team gave easy and the other complex instructions. In these cases, the lightly instructed teams wanted extra time to refine their assignment and realized that they had not taken the assignment seriously.

Interesting discussions also took place during the verification of the implementation. Although the students did not communicate in their native languages, they defended their positions, argued and accepted their mistake, if any. The students themselves and their teachers shared that they learned a lot about logic in a fun and light way during these plays.

As common errors, we can note the misunderstanding of the conditional operator, especially in its complete form, as well as difficulties with the "OR" and "NOT" operators. Some participants (about 5 – 10%) got carried away in drawing and forgot about the given description.

The observations on the participants from the different groups give us reason to assume that the proposed solutions are closely related to the cognitive thinking style of the players.

There are different classifications of cognitive thinking styles. "In general, however, two fundamental orientations dominate: 'analyzers' (dividers) who tend to analyze information logically and divide it into smaller parts and 'integrators' (unifiers) who tend to observe the whole and the relationships between the parts." Quoted in (Ivanov 2004).

For example, "analyzers" tend to offer accurate pictures that correspond to the given task, but realized in the lightest way and without introducing author's elements. "Integrators", on the other hand, try to offer more complex-looking paintings, insert author's elements, use different colors and go beyond the limits of a single sheet in their work. They make mistakes more often. At this stage, these are assumptions for which data is yet to be accumulated to test the given hypothesis.

Conclusions

The data obtained give us reason to assume that the game "Logic Monsters" has a place in the lessons of various subjects. It is easy and does not take much time. The teacher should choose the technological option and the cognitive variation according to the didactic goals of his lesson and the individual characteristics of his students.

The game is to be applied and further developed by tracking the correlation of the proposed types of solutions and the cognitive type of thinking of the students proposing the corresponding type of solution.

The game is a powerful didactic tool only when it is applied correctly and according to the attitudes and desires of the students. Achieving effective and enjoyable learning cannot be achieved through game approaches alone, but can be complemented by the application of appropriate games. Teachers welcome ideas

for play approaches that they can easily modify to suit their subject and students' needs.

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