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WHICH OLYMPIAD PROBLEMS DO STUDENTS TAKE TO THE BOARD? CHOICES AND DEFENCES IN THE 8TH-GRADE LEAGUE OF KARAGANDY MATHBATTLES 2026

Abstract: A mathematical battle is a team competition in which two teams solve the same set of problems and then challenge each other to present solutions at the board. A challenged team can accept the challenge or refuse it, so every battle records a decision about each problem. In this study I used the jury protocols of the 8th-grade league of Karagandy Mathbattles 2026, a tournament where I was one of the organisers and a member of the jury, to find out which problems teams take to the board and how successful their defences are. I transcribed all 16 battles of the league (8 teams, 96 challenges on 30 different problems), checked every battle against the jury's total, and labelled each problem as algebra, geometry, combinatorics or number theory. Teams accepted 68% of challenges on combinatorics problems, but only 46% on geometry, 42% on algebra and 38% on number theory (combinatorics against the other topics, Fisher's exact test $p = 0.05$). When a geometry challenge was accepted, the speaker almost always gave a complete solution (10 of 11 reports received the full 12 points, mean 10.9), while accepted number theory problems received a mean of 6.4 points and only 3 of 10 full solutions (permutation test $p = 0.03$). In 30 of the 49 refused challenges the challenging team could not defend its own challenge, so the refusing team received 6 points. Stronger teams accepted challenges more often than weaker ones. The results suggest that teams take geometry to the board only when they are sure, take combinatorics more boldly, and avoid number theory, which was also the topic in which students were least successful at the board. Because the data come from one league of one tournament, these patterns should be checked on more tournaments.

Keywords: mathematical battle; mathematics olympiad; problem solving; team competition; problem difficulty; Kazakhstan

Introduction. Most mathematics olympiads are individual: a student writes solutions on paper and the jury marks them later. Competitions have long been an important part of mathematics education [1], and over the last decades many team competitions have appeared next to individual olympiads [2]. One of them is the mathematical battle (in Russian "математический бой", or "matboi"), which comes from the tradition of mathematical circles in the former Soviet Union [3]. In a battle, two teams get the same problems and solve them in separate rooms. After that they meet, and the teams take turns challenging each other: one team names a problem, and the other team decides whether it will present the solution at the board [4, 5].

I have taken part in the organisation of Karagandy Mathbattles, a tournament for students of the 7th and 8th grades, and in 2026 I was also a member of the jury. From the jury table it is

easy to see that teams do not treat all problems in the same way. Some problems are accepted almost every time, while other problems are refused even by strong teams. Every refusal is a decision with a cost, because a team that refuses a problem cannot score the full 12 points for it. This means that the protocols of a battle show not only which problems were solved, but also which problems students felt confident enough to defend in front of an opponent and a jury. In research on problem solving, the ability to judge and control one's own work is called metacognition, and it is considered an important part of thinking mathematically [6].

Olympiad problems are usually divided into four areas: algebra, combinatorics, geometry and number theory. This division is used, for example, in the shortlist of the International Mathematical Olympiad [7]. I did not find a published study that uses the protocols of mathematical battles to compare these areas, and the rules of a battle make such data unusual, because they record both the decision about a problem and the result of its defence. In this study I asked three questions:

- Which topics do teams accept to present at the board, and which do they refuse more often?
- When a challenge is accepted, how successful is the defence in each topic?
- What happens when a challenge is refused, and do stronger teams accept challenges more often?

The rules of a mathematical battle. The rules used at Karagandy Mathbattles follow the usual rules of mathematical battles [4, 5]. Each battle has six problems (in the final the teams had 1 hour 30 minutes to solve them). Each problem is worth 12 points, which are divided between the speaker, the opponent and the jury. A speaker who gives a complete and correct solution receives all 12 points. The opponent's task is to find gaps in the solution, and the opponent receives points for the gaps that he finds. The points that neither side earned stay with the jury.

When a team is challenged, it can accept or refuse. If it accepts, it sends a speaker to the board and the challenging team sends an opponent. If it refuses, the challenging team must show that it has a solution itself. This is called the check of the correctness of the challenge. If the challenging team admits that it has no solution, or if the opponent proves that the solution is not there, the challenge is called incorrect, the refusing team receives 6 points and the challenging team has to make another challenge [5]. The jury can also give penalty points, usually -1, for breaking the rules, for example for talking to a teammate at the board.

Data and methods

The tournament. I used the 8th-grade league of Karagandy Mathbattles 2026. Eight teams took part. The teams played three group rounds of four battles each, then two semifinals, a match for third place and the final, which makes 16 battles. Each battle had six problems, so the data contain 96 challenges. The three group rounds and the semifinals had their own sets of problems, and the final and the match for third place used the same set, so there were 30 different problems in total.

Transcription. After every battle the jury writes the protocol on the whiteboard: for each problem, the number, the names of the speaker and the opponent, the points of each side, the jury's points, penalties and whether the challenge was accepted. These protocols were photographed. I transcribed them into a table with one row per problem in each battle. During this work I found that Google Sheets had changed some entries such as "12-1" (12 points and a penalty of 1) into dates, so I moved penalties into separate columns and entered all points as numbers.

Checks. The sum of the points in the six rows of a battle must be equal to the total written by the jury. After all corrections, this was true in 15 of the 16 battles. In one battle of the first round the protocol said 29 points for one team, but the points for its problems add up to 30, so the jury made an arithmetic error. For the final there is no photo of the protocol, and the score of 31:27 comes from a member of the jury. I kept both of these facts in the data and mention them here. In one challenge, in the match for third place, both teams refused to present the problem. This challenge is counted in the number of challenges but not in the analysis of defences.

Topics. I labelled each problem by its main topic, using the statement and the official solution. Five of the 30 problems combine two topics, for example a problem about subsets that is solved with algebra. For them I chose the main topic by the method of the solution, and as a robustness check I repeated the calculations giving half of such a problem to each of its two topics. By main topic, the 96 challenges include 26 on number theory, 24 on algebra, 24 on geometry and 22 on combinatorics.

Measures and tests. For each topic I calculated the share of challenges that were accepted and, for accepted challenges, the points of the speaker. For refused challenges I counted how often the challenge was found incorrect, which I defined as the refusing team receiving 6 points while the challenging team's speaker received no more than 5. To test whether acceptance depends on the topic I used the chi-square test and Fisher's exact test. Because stronger teams may accept more problems, I also used a permutation test [8] in which the topic labels were shuffled 10,000 times only within the challenges received by the same team. To compare speaker points between topics I used the Kruskal-Wallis test [9] and a permutation test for the difference in means. To describe the strength of a team I used its average number of points per battle. All calculations were made in Python.

Results

Which problems are taken to the board. Teams accepted 46 of the 96 challenges (48%). The share was very different between topics (Table 1 and Figure 1). Combinatorics was accepted in 15 of 22 challenges (68%), geometry in 11 of 24 (46%), algebra in 10 of 24 (42%) and number theory in 10 of 26 (38%). The chi-square test for all four topics was not significant ($p = 0.17$), and the result was the same when topics were shuffled only within each team ($p = 0.17$). However, combinatorics stands out from the other three topics: the odds of accepting a combinatorics challenge were 2.9 times higher than for the other topics together (Fisher's exact test $p = 0.05$). With only 96 challenges, I think this should be read as a clear tendency rather than a proven difference.

Table 1. Challenges by the main topic of the problem

Topic	Challenges	Accepted, %	Mean speaker points (accepted)	Full solutions (accepted)	Incorrect challenges (refused)
Geometry	24	46	10.9	10 of 11	7 of 12
Combinatorics	22	68	8.9	9 of 15	4 of 7
Algebra	24	42	7.9	5 of 10	9 of 14
Number theory	26	38	6.4	3 of 10	10 of 16

One geometry challenge, in which both teams refused, is counted among the challenges but not among accepted or refused ones.

Some problems were never accepted. In the group stage, where each problem was given in four battles, two problems were refused every time: a geometry problem about a rectangle in the first round and an algebraic inequality in the third round. Both number theory problems of the final set were refused in the final and in the match for third place, and the number theory problem of the semifinals was refused in both semifinals.

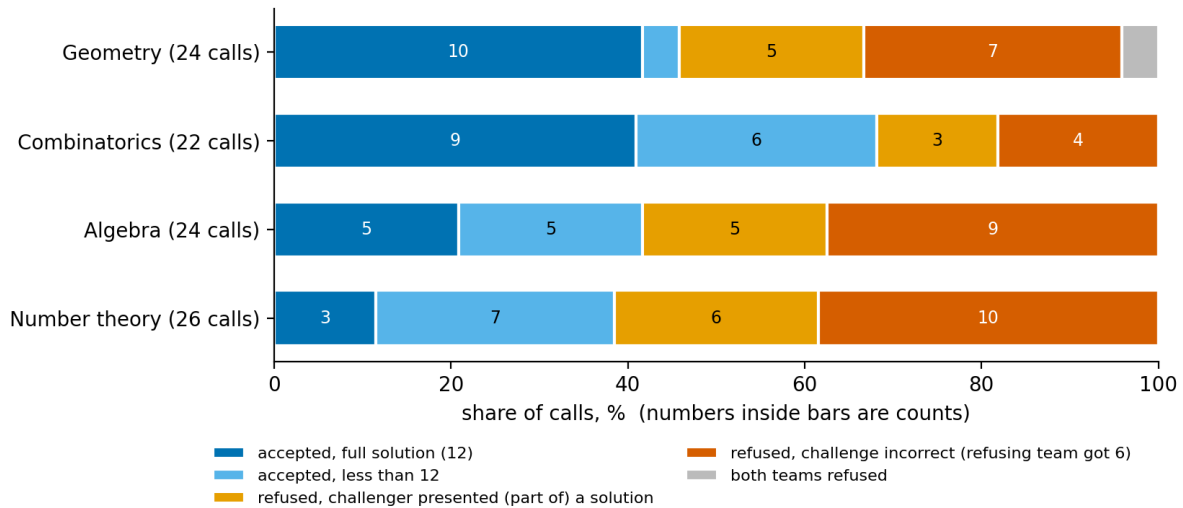


Figure 1. What happened to the challenges in each topic

How successful the defences were. When a challenge was accepted, the speaker received on average 8.6 points, and 27 of the 46 reports (59%) were complete solutions worth 12 points. The topics differed a lot (Figure 2). In geometry 10 of 11 accepted reports received the full 12 points, and the mean was 10.9. In combinatorics the mean was 8.9 with 9 complete solutions out of 15, in algebra 7.9 with 5 out of 10, and in number theory only 6.4 with 3 out of 10. The Kruskal-Wallis test for all four topics gave $p = 0.08$, and the difference between geometry and number theory, 4.5 points, was significant in a permutation test ($p = 0.03$).

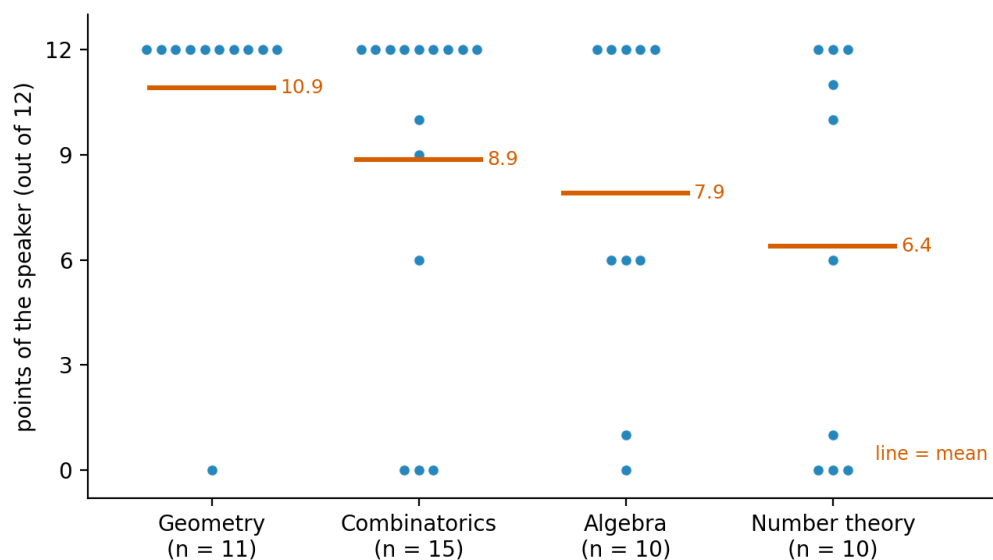


Figure 2. Points of the speaker in accepted challenges, by topic

Geometry and combinatorics therefore behave differently. Geometry was accepted less often than combinatorics, but when it was accepted, the solution was almost always complete. Combinatorics was accepted more often, and more of these defences ended with a partial solution. My explanation is that in geometry students know quite well whether their proof is finished, while in combinatorics it is easier to believe that a solution is correct when it still has a gap, and the opponent can find it. Number theory was both the least accepted topic and the least successful one at the board.

The robustness check with half weights for the five problems with two topics gave the same order: geometry still had the highest mean (10.9) and number theory the lowest (6.6), and combinatorics was still accepted most often (61%).

Refusals and the strength of teams. Of the 49 refused challenges, 30 (61%) turned out to be incorrect: the challenging team did not have a solution, and the refusing team received 6 points. In only 11 refusals did the challenging team present a complete solution itself. Incorrect challenges were most common in number theory (10 of 16) and algebra (9 of 14). This means that often neither team had a solution to the problem, and the refusal was a reasonable decision. On average, a challenged team received 8.6 points when it accepted and 3.8 points when it refused.

Stronger teams accepted challenges more often (Table 2). The three medal teams accepted between 47% and 61% of the challenges they received, while KarErBIL-2 and Daryn, two of the weakest teams, accepted 25% and 33%. The weakest team, Burabay, is an exception with 50%, but it received only 8 challenges. The rank correlation between a team's average points per battle and its acceptance rate was 0.63, but with only eight teams this was not significant ($p = 0.09$). Because strong teams play more battles, I also checked the topic results within teams, as described in section 3, and the conclusions did not change.

Table 2. Teams of the 8th-grade league

Team	Battles	Points per battle	Challenges received	Accepted, %
AstBIL (1st)	5	42.4	18	56
KarErBIL-1 (2nd)	5	40.4	18	61
Shymkent (3rd)	5	36.0	15	47
Kostanay	3	21.3	9	56
Nurmakov (4th)	5	13.8	10	40
KarErBIL-2	3	9.0	8	25
Daryn	3	6.3	9	33
Burabay	3	3.7	8	50

Team names are written as in the protocols. Places are given for the teams that reached the semifinals.

Discussion. The main result of this study is that the topic of a problem matters both for the decision to take it to the board and for the result of the defence. Combinatorics was accepted most often, geometry was accepted carefully but defended almost perfectly, and number theory was avoided and, when accepted, often not finished. In the 8th grade, number theory problems often need a key idea, such as looking at remainders or at the prime factors of both sides, and without this idea a student may have nothing to show. A geometry proof, in contrast, is either

finished or clearly not finished, so a team knows before the battle whether it can defend it. I cannot check these explanations with protocols alone, but they fit the pattern in the data.

The refusals show another side of a battle. In 61% of refusals the challenging team did not have a solution either. Under the rules, a team sometimes has to challenge on a problem that it has not solved, and the other team can use this by refusing. The data suggest that refusing was often a good decision, because in most refusals the challenging team could not defend the problem either.

For the organisers of tournaments like ours, the results give two practical ideas. First, if almost all teams refuse the same problem, as happened with the two group stage problems and the number theory problems of the final set, that problem probably did not work as part of the battle, and the jury can see it from the protocols. Second, a balanced set may need easier number theory problems than geometry problems, if the jury wants every topic to be taken to the board. The protocols also showed that the jury itself can make arithmetic mistakes: in one of 16 battles the written total was wrong by one point. Checking the sum of the rows against the total is simple and could be done after every battle.

Limitations. The data come from one league of one tournament: 8 teams, 16 battles and 30 problems. For this reason several differences, especially in acceptance, are only tendencies. The topics are connected with particular problems, so a very hard geometry problem or a very easy combinatorics problem can change the result for the whole topic. The labels of topics were made by me, and five problems could belong to two topics. Strong teams played more battles, which I tried to control with a test within teams, but with eight teams this control is limited. The protocol of the final is not available, and its score is based on the words of a member of the jury. Finally, I was a member of the jury myself, and although the points were given by the whole jury, my knowledge of the tournament may influence how I interpret the results.

Conclusion. Using the jury protocols of 16 battles of the 8th-grade league of Karagandy Mathbattles 2026, I found that teams accepted combinatorics problems most often (68%) and number theory problems least often (38%). Accepted geometry problems were almost always solved completely (mean 10.9 of 12 points), while accepted number theory problems received only 6.4 points on average. In 61% of refusals the challenging team had no solution either. Stronger teams accepted challenges more often. These results show that the protocols of a mathematical battle are a useful source of data about how students judge their own solutions, which is a part of metacognition [6]. The next step would be to repeat the analysis on the 7th-grade league of the same tournament and on other tournaments, to see whether number theory is avoided there as well.

Author contribution and use of AI. The author was one of the organisers and a member of the jury of the tournament, collected the photos of the protocols and the problem sets, transcribed all 16 battles into the table, found and corrected the errors in it, labelled the topics of the problems and made the first summary table by topics. The author's mentor checked the table against the protocols, carried out the statistical analysis, made the figures and helped write and edit the English text. Generative AI tools were used to help with editing and translation. Every number in the paper was calculated from the table by the analysis code and checked by the author's mentor.

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