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Organization and Results of Mongolian National Online Olympiads in Informatics

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Abstract. Incorporating coding skills into the basic literacy skills of 21st century citizens is common in many parts of the world. This is because the development of artificial intelligence and smart devices and their social use have become real, and in the near future, the ability to use robots and artificial intelligence devices for their own purposes has become a skill that every citizen should have. Algorithms and programming are included in the Mongolian general education information technology course curriculum. The coding ability plays an important role in the development of a new century citizen's thinking, creating and evaluating skills. One of the activities that promotes the development of this skill is the International Olympiad in Informatics. Our country has been participating in this Olympiad since 1991 and has won three bronze, one silver and one gold medal. You can participate in the online Olympiad regardless of where you live in Mongolia. This type of Olympiad is very important to support the continuous development of students who are gifted in programming and coding, as well as to enable them to successfully participate in national and international Olympiads.

Mongolian Informatics Olympiad Committee (MIOC) organized 24 online contests using Contest Management System (CMS[1]) which is official IOI judging system. In this paper we considered 22 online contests organized in 2019, 2020, 2021 years and classified 115 problems chosen in those contests by topics and complexity. We also report here results of a small research about scores got by participants, development of problem-solving skills. A new registration web system developed while implementing IOI judging system is explained.

Keywords: informatics, programming, grading system, olympiad, online judge system.

[1] Open-source contest management system. `https://cms-dev.github.io/`

Introduction

Contest Management System (CMS) is a system developed by Italian software engineers and there was a successful localization for Mongolian language in 2015. Now it is being used in following olympiads.

- Among high school teachers and students:
  - District level olympiads for 9 districts in Ulaanbaatar city.
  - 21 provinces and capital city informatics olympiads.
  - National Olympiads in Informatics.
  - Contests for selecting IOI participants.
  - Online olympiads.
- Among university students:
  - Algor-ithm and programming related courses.
  - Programming olympiads inside a university.
  - State level Programming Olympiad for University students.

In order for the competition to be successful, it is important to support participation of people by connecting people with similar interests such as informatics and problem-

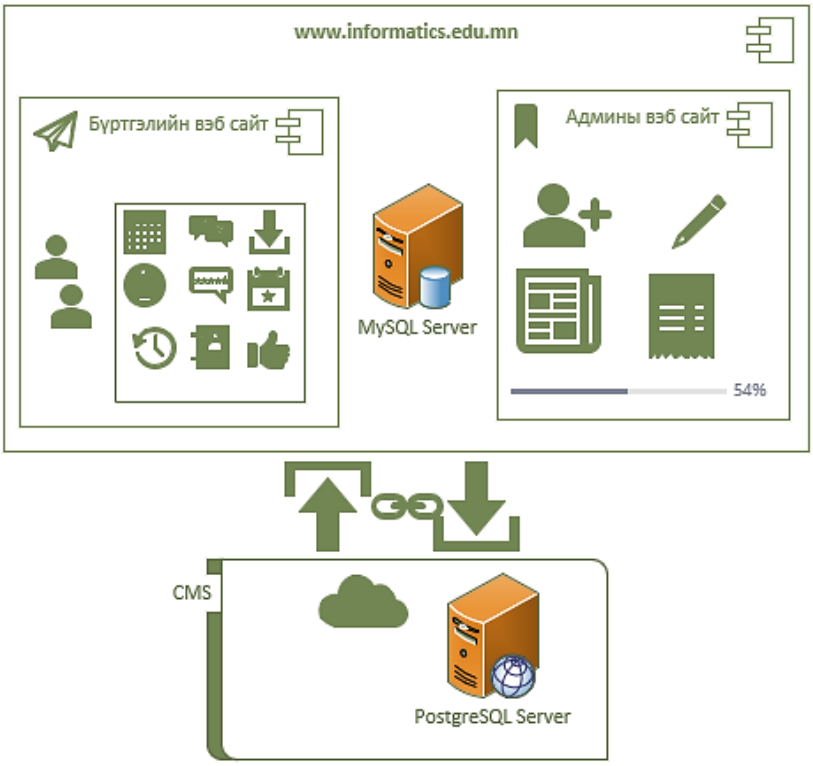


Fig. 1. Cooperation of CMS and Informatics olympiad registration website.

solving. We must pay attention to provide a good networking environment among people interested in programming from different areas of study therefore to improve their chances to develop together. (Amaroli, Audrito & Laura, 2018).

Development of a web registration system used for olympiad participants, alumni's, statistical processing, exporting information for CMS started in December 2017 and finished in January 2018.

The website `www.informatics.edu.mn/burtgel` consists of participant registration page and admin page. It is currently being developed continuously (Dashdemberel & Ulambayar, 2017).

These systems were designed to work with CMS and official MIOC website. Our next step is developing a continuous online contest system and it is being tested in local environment. These two websites have shared database and both exchange information with CMS while working.

These are the two systems we have developed.

About CMS v1.4

Since 2015 we are using CMS (`http://cms-dev.github.io/`) (Maggiolo and Mascellani, 2012; Maggiolo *et al.*, 2014) for each level of programming and informatics olympiads in Mongolia.

We use CMS 1.4 for online and offline contests. Fig. 2 shows basic CMS operations (Maggiolo and Mascellani, 2012).

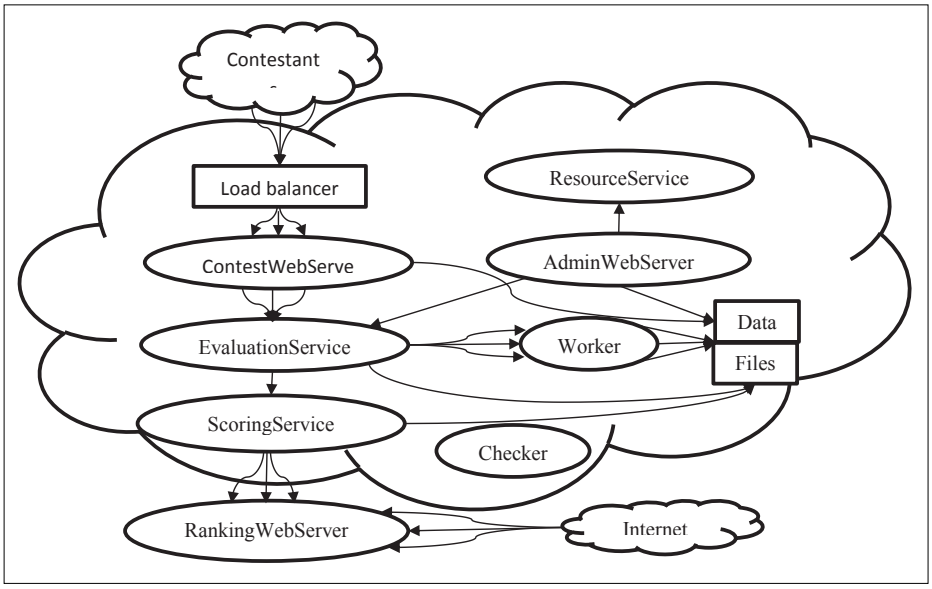


Fig. 2. Basic CMS operations.
(Source: Maggiolo and Mascellani, 2012)

AdminWebServer is a admin web service to provide contest organizers with operations such as insert, edit participants' information, view participants' solutions, contest ranking and download them.

ContestWebServer has mainly participant operations such as get contest information, download problem statements, ask questions about a problem, send solutions, view own scores. This server program is duplicated and loaded on several servers using load balancer when the contest size is big.

EvaluationService distributes contestants' solutions to Worker threads to check them. Then it takes results of each test and sends it to ***ScoringService*** service. Each Worker thread gets participant code, recognizes programming language used, compiles the code using corresponding compiler to get an executable, runs it to get results of each test and writes it to the database.

ScoringService combines evaluated scores for each test from ***EvaluationService*** and sends total score to ***RankingWebServer*** web page. ***RankingWebServer*** lists all participant scores and publishes the list on website.

There were following additional requirements in process of localization.

1. Automatically register, create passwords, insert into CMS system, create certificate for each contest. This leaded us to develop our website.
2. Create problem archive after classifying problems by type and level. Register users on the web, change rank list view, organize open contests.
3. Create beginner, middle, advanced level training website to increase participant count. Students will be able to send request for training material and improve their skills. This kind of training website can be replaced by Moodle LMS.

Focusing above requirements we have developed a registration website which cooperates with CMS system.

One can read about organization of programming and informatics contests among high school students, improvement of students' participation in this kind of contests, online learning platforms for computer science courses in many papers by international researchers (William, Gabriele, Luigi, Umberto, Marco & Luca, 2016).

Our web system consists of administration and user registration sections.

a. Administrator website v2.0.

Actions allowed for admin user

- Manage registered users (Add into active contest as a contestant, enable or disable log in permission, remove participant).
- Check registered participants' information of an announced contest and confirm or cancel contest participation requests.
- Automatically create username and password for CMS system and email them to confirmed participants. Publish usernames on the website.
- Send e-mail to users.

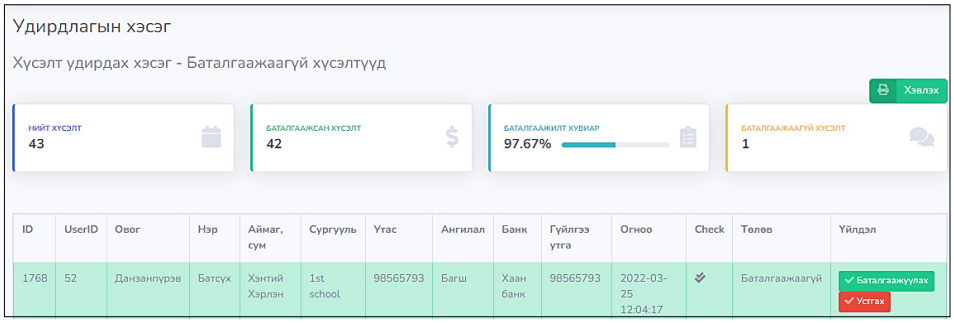


Fig. 3. Control panel of admin website.

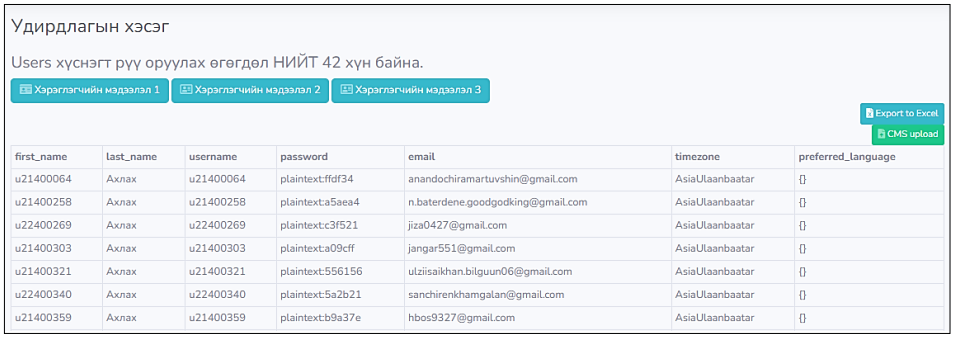


Fig. 4. User list.

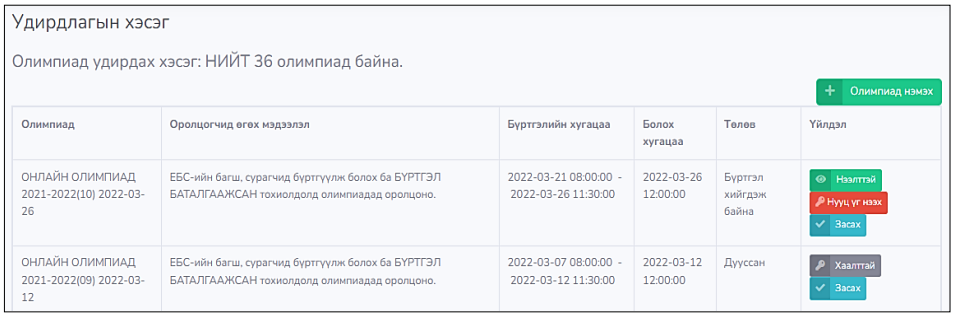


Fig. 5. Contest list.

- Prepare data for a CMS contest and export. Upload teachers' and students' information into CMS.
- Manage contests (add, activate, open, close).
- Add, manage additional materials for contestants.

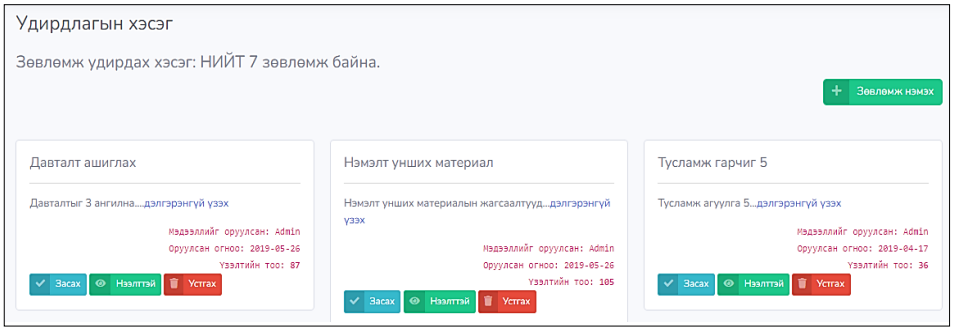


Fig. 6. Additional materials page.

b. Registration website v2.0

Actions allowed for users

- Register, log in, restore password, change password.
- Send request to active contest. In case of confirmation get username and password.
- View contest rank list, problem statements, solutions and problem statistics. Download tests for a problem.
- Download problem statements, solutions and tests from problem set.
- View additional materials.
- Go to additional olympiad problem sets.
- Download certificate of participation.

The registration website also has some extra pages for regulations, training materials, problem set, certificates. The problem set consists of 450 problems. Users can download problem statements, solutions, tests. Problems are classified into 4 complexity groups

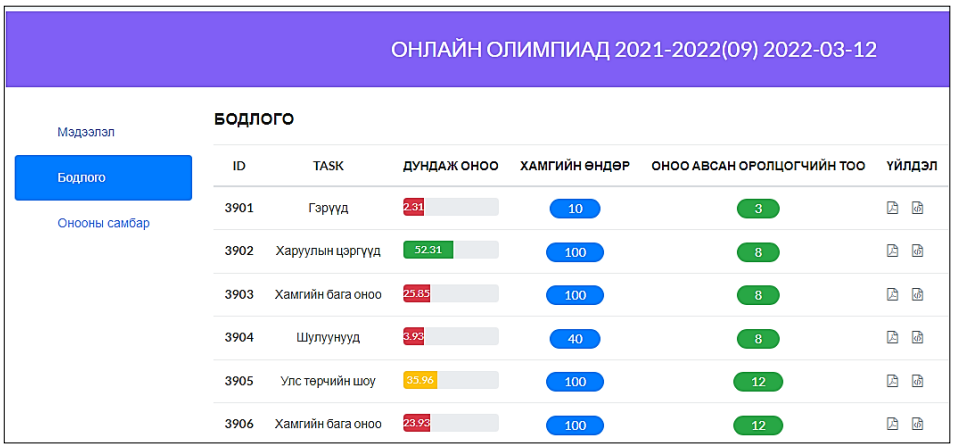


Fig. 7. Problems list.

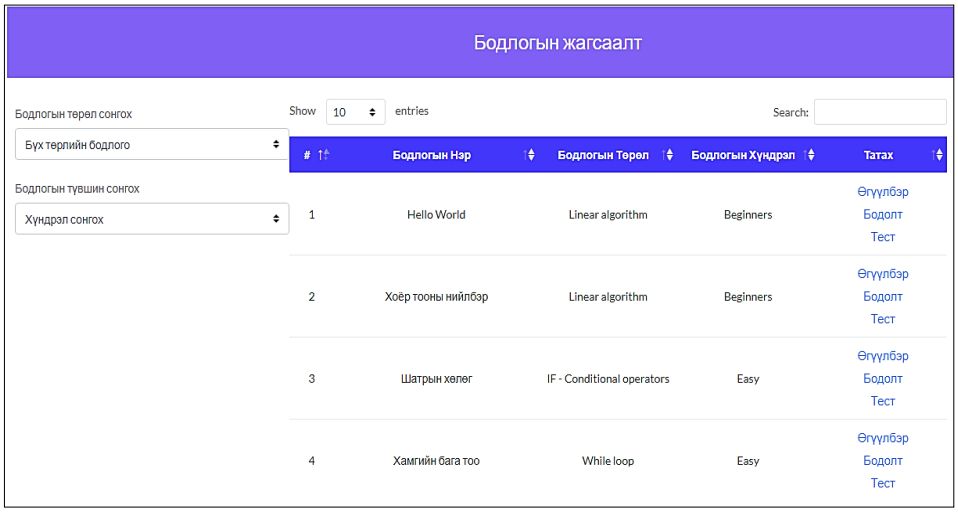


Fig. 8. Problem statement, solution and tests list.

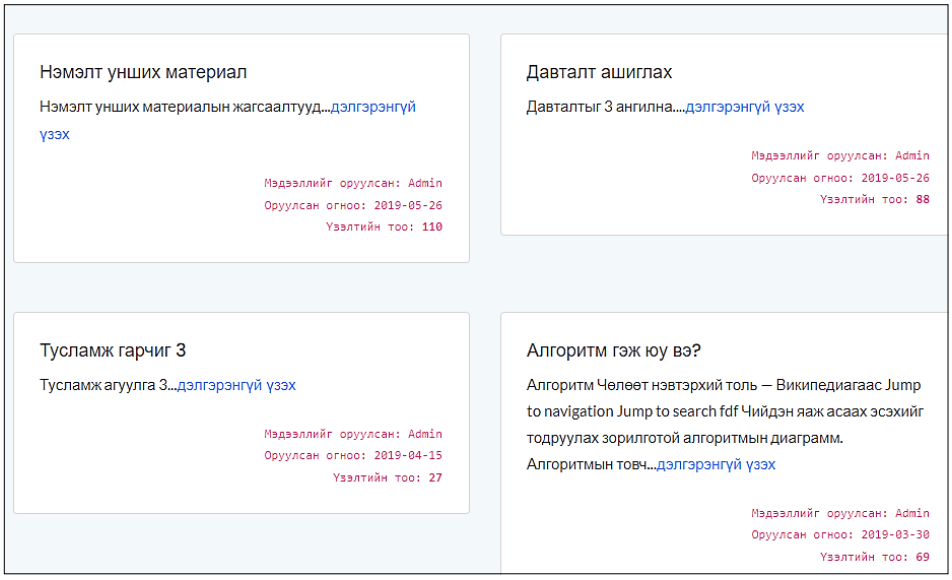


Fig. 9. Additional materials page.

and 25 topics. These problems can be used by beginners, olympiad participants. Also, they will be useful in programming and algorithm courses of Information technology, Computer Science, Software Engineering undergraduate programs.

Influences of the Online Olympiads

Highschool students are facing several difficulties due to their English language barrier. The most widely spread difficulties are being not able to participate in online programming contests in English, using online resources in English, difficulties with understanding problems in English etc. Regular participation in online contests helps them make programming and algorithmic skills better. Also, online contest rankings of our students show us their readiness for international level competitions (Khuder & Tsedevsuren, 2016).

The top informatics olympiad skills are algorithmic skills, self-study, using programming tools, digital8 technological and technical skills, communication skills and creativity (Tsvetkova, Kiryukhin, 2020). It is very important to organize regular online contests which are considered as exercise environment for developing these skills.

The most important information source about above topics is the proceeding of IOI conference – "Olympiads in Informatics" (international forum for presenting research and development in the specific area of teaching and learning informatics through competition) first publication of which was in 2007. Books such as (Skiena and Revilla, 2003) and (Halim and Halim, 2013) includes important materials about programming contests, algorithms, data structures and computer science (William, Gabriele, Luigi, Umberto, Marco & Luca, 2016).

Dagienė (Dagienė, 2010), Garcia-Mateos and Fernandez-Aleman (Garcia-Mateos and Fernandez-Aleman, 2009) noted about importance and influence of programming, computer science olympiads in studying computer science.

The core element and skill of programming education is basic coding skills which includes programming according to programming language syntax and problem solving. Students should learn both basic algorithms and their implementations. There are two basic types of errors in code: syntax and static sematic errors, dynamic semantic errors. While errors of first type are discovered by compiler, for the second type errors require testing. Students should improve their skills of making tests.

First online open contest was organized in 15th of March, 2018 and then we tested these webpages. Here we showed only main statistics. Each user registers with his email and email defines unique user. We send confirmation email and after user confirms it he or she will be able to use the system. Now we have 721 users in our contest registration website (51 of them did not confirm their email). Hence, we have around 670 active users.

There were 495 participants from Ulaanbaatar city, 175 participants from provinces. Top 4 provinces by participant count were Uvs (43), Uvurkhangai (26), Darkhan city (20) and Bayankhongor (11). Average participant count among 20 provinces was 8,75. Recent years' top provinces by participant scores in National Olympiads in Informatics are Uvs, Darkhan city, Bayankhongor, Khubsugul, and Khobdo. Participants visiting statistic was between 1 and 192. Average visit count was 11,4. Since the website was created there were made 7692 visits. There were 735, 1378, 1168, 4411 visits in years 2018, 2019, 2020 and 2021. Visiting count of the webpage for the first week of January, 2022 is 532.

Table 1
Classification of contestants

Classification	Count
Teacher	79
Senior	132
Secondary	78
Other	27
Total	**316**

Table 2
Participants and problem statistics

Year	Olympiads organized	Contestant count					Problems	
		Teacher	Senior	Secondary	Other	Total	Teacher	Student
2019	4	46	50	25	25	**146**	4	4
2020	8	8	13	1	7	**29**	5	5
2021	10	13	9	10		**32**	4	4
Total	22	317	386	172	29	**904**	82	84

As of today, we have organized 24 online contests in total. There were 2 contests in 2018, 4 in 2019, 8 in 2020 10 in 2021. This paper covers results and analysis of 22 online contests from 2019, 2020, 2021 years. A total of 904 teachers and students participated in the 22 Olympiads, 115 problems were proposed and a database of results was formed.

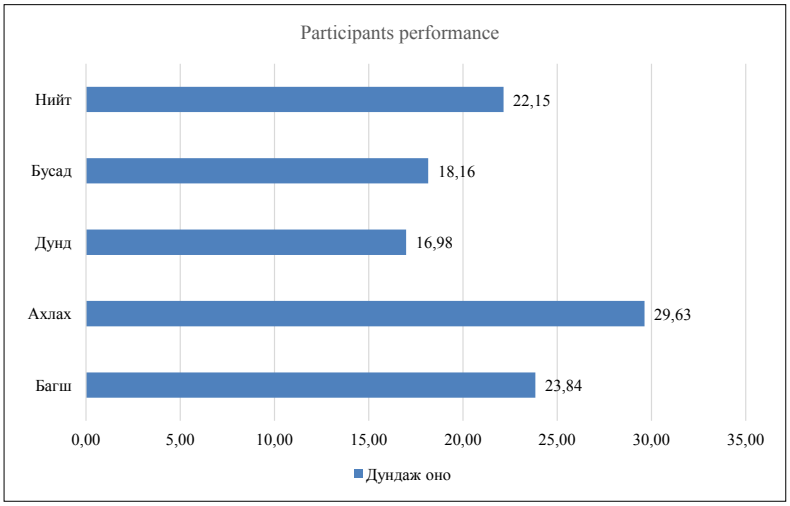
Statistical information shows there are 79 teachers and 210 students among participants. Recent years amount of teachers increased and it also make amount of students interested in programming. Reason of this may be scholarships in foreign universities and former olympiad participants who works now in world level IT companies such as Google, Facebook, Amazon, Microsoft. Total amount of participants in 22 online contests was 316. Table 1 shows number of participants by classification.

Participant count of our online olympiad was between 11 and 77. There were 22 online olympiads organized and in average there were 18 teachers, 22 students in each contest (average contestant count was 41). Each contest has 3–4 problems. There were 10 online contests in 2021 and each has two categories: teachers and students. After adding category "Teachers" number of teacher-participants is steadily increasing.

Above performance statistics show us the Senior students get the best scores. Also, we can see the average performance of teachers and senior students are higher than the general average by 1.7 and 7.5 percent correspondingly.

115 problems used in contests were classified into 4 levels and there were 4 easy level problems, 30 middle level, 51 hard level and 30 advanced level problems. We can see the average score of performance was decreasing with the increasing level of problem.

Performance per complexity of the problems is shown in Table 3.



Graphic 1. Participants performance.

Table 3
Performance by problem complexity

Problem complexity	Full solution	50–99 scores	Less than 50 scores	0 scores	Average score
Easy	38	38	13	29	60.28
Middle	191	118	147	435	34.97
Hard	208	98	248	807	23.85
Advanced	56	38	110	654	11.55
	493	292	518	1925	32.6625

Table 4
Time and performance

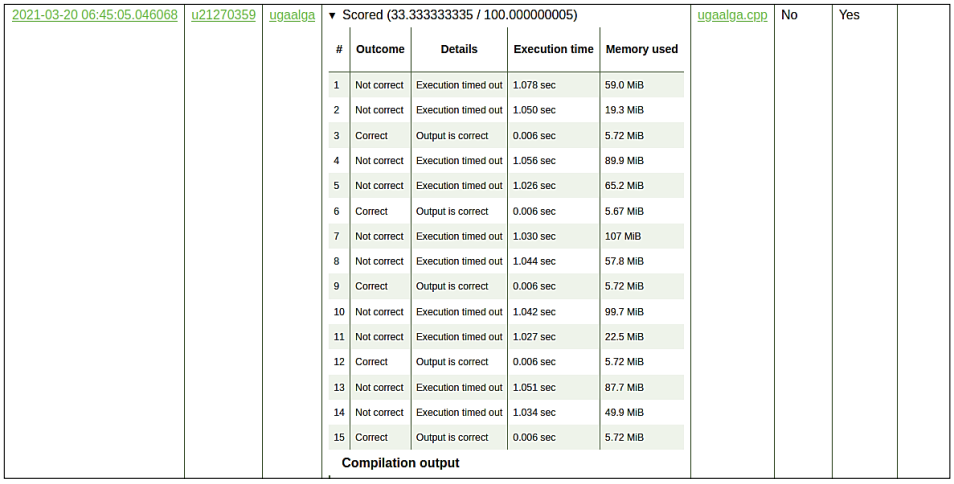
Time (c)	Problem count	Full solutions	50–99 scores	Less than 50 scores	0 scores	Average score
0.1	3	10	2	16	63	14.76
0.5	41	125	57	134	393	26.99
1	55	258	116	221	850	26.95
1.5	2	1	12	2	51	11.29
2	10	10	5	23	136	10.22
2.5	1	0	2	2	23	7.96
3	3	14	28	19	41	36.17
Total	**115**	**493**	**292**	**518**	**1925**	**19.85**

Time and memory limits are main settings for a informatics problem. We used mostly time limits for problems and memory limits are not widely used. Running times of participant solutions are shown in Table 4.

We can see from the above table that from all solutions there are full solutions – 16.0%, solutions which got between 50–99 points – 8.5%, solutions with less than 50 points – 16.0%.

All 115 problems used in online contests can be classified into 12 classes. Table 5 shows performance in 4 levels for each class of problems.

Our problem classification matches with important topics in IOI syllabus. We should develop training materials according to IOI syllabus. Insufficient knowledge and skills from IOI syllabus leads to poor planned training and unsuccessful IOI participation (Khuder, Tsedevsuren, 2016). Therefore we should pay attention to improve those skills of students which gives us bad average score.



2021-03-20 06:45:05.046068 | u21270359 | ugaalga | ▾ Scored (33.333333335 / 100.000000005) | ugaalga.cpp | No | Yes

#	Outcome	Details	Execution time	Memory used
1	Not correct	Execution timed out	1.078 sec	59.0 MiB
2	Not correct	Execution timed out	1.050 sec	19.3 MiB
3	Correct	Output is correct	0.006 sec	5.72 MiB
4	Not correct	Execution timed out	1.056 sec	89.9 MiB
5	Not correct	Execution timed out	1.026 sec	65.2 MiB
6	Correct	Output is correct	0.006 sec	5.67 MiB
7	Not correct	Execution timed out	1.030 sec	107 MiB
8	Not correct	Execution timed out	1.044 sec	57.8 MiB
9	Correct	Output is correct	0.006 sec	5.72 MiB
10	Not correct	Execution timed out	1.042 sec	99.7 MiB
11	Not correct	Execution timed out	1.027 sec	22.5 MiB
12	Correct	Output is correct	0.006 sec	5.72 MiB
13	Not correct	Execution timed out	1.051 sec	87.7 MiB
14	Not correct	Execution timed out	1.034 sec	49.9 MiB
15	Correct	Output is correct	0.006 sec	5.72 MiB

Compilation output

Fig. 10. CMS view of a participant solution.

Table 5

Problem classification and performance

Classification	Full solutions	50–99 scores	Less than 50 scores	0 scores	Average score	Problem count
Linear algorithm	14	1	0	5	72.5	1
Number theory	158	125	113	282	39.79	27
Strings	27	16	57	94	28.39	8
Dynamic programming	47	36	106	253	21.27	14
Geometry	85	40	97	413	20.97	24
Sequence and sorting	80	41	57	409	20.39	20
Other	15	2	8	61	20.02	3
BFS	12	2	21	55	17.00	2
2D array	10	3	13	44	18.93	4
DFS	18	7	19	112	17.74	5
Graph theory	27	19	27	197	17.07	7
Total	493	292	518	1925	25.92	115

Батламжууд

#	ОЛИМПИАД	АВСАН ОНОО	ҮЙЛДЭЛ
1	ОНЛАЙН ОЛИМПИАД 2020-07 2020-04-17	260	ТАТАХ
2	ОНЛАЙН ОЛИМПИАД 2020-06 2020-04-10	310	ТАТАХ
3	ОНЛАЙН ОЛИМПИАД 2020-05 2020-04-03	300	ТАТАХ
4	ОНЛАЙН ОЛИМПИАД 2020-04 2020-03-27	400	ТАТАХ
5	ОНЛАЙН ОЛИМПИАД 2020-03 2020-03-21	378	ТАТАХ

Fig. 11. Certificate list.

Conclusion

After regular online olympiads participants' problem solving and technical skills are improving. There were no "Teacher" category in 2018–2020 and not many teachers participated but after adding the category teacher count has increased. We can also set up categories "beginner", "middle" and "advanced" in registration and CMS webpage.

Organizing regular online olympiads increases interest in "Competitive programming, participant number and also student numbers studying algorithms. Now we are going to define hard topics for students and create online learning content about them. This will help us improve general programming skill level of participants. There are additional online learning materials for dynamic programming, graph algorithms, computational geometry created by teachers and published for students. Another important result of regular online contests is practicing and improvement in time management, learning to choose which problem to try first in IOI.

Mongolian IOI team got IOI medals for past 4 years. We conclude that our online contests have some influence in those successful participations. Specifically, Tenuun got bronze medal in 2018, Nyamdavaa got two silver medals in 2019 and 2021. He also got his gold medal in 2020. In total Mongolian team got 6 medals from IOI.

We strongly believe that organizing regular online contests can be strong educational support for improving coding and algorithmic thinking skills for informatics teachers and students.

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Online resources

Dashboard with System's metrics for Mongolian Online Olympiad. URL:
`https://informatics.edu.mn/burtgel`
Dashboard with System's metrics for Russian Programming Olympiad. URL:
`https://olympiads.ru`
Contest of codefoeces.com online judge. URL:
`https://codeforces.com/contests`
Contest of e-olymp online judge. URL:
`https://www.e-olymp.com/en/contests`
Achievements in Mongolia's IOI. URL:
`http://stats.ioinformatics.org/results/MNG`

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