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National Olympiad in Informatics: Sri Lanka

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Abstract. The National Olympiad in Informatics (NOI) in Sri Lanka is an annual programming competition for students in Sri Lanka. The competition aims to identify and encourage talented young programmers in the country. The competition consists of several rounds, including training rounds, a screening round, a national round, and a training camp for the top performers. The problems in the competition are designed to test the students' programming skills, algorithmic thinking, and problem-solving abilities. The NOI Sri Lanka competition plays an important role in promoting the development of computer science and programming skills among young people in Sri Lanka.

Keywords: IOI, programing olympiads, informatics, distance learning, informatics.

1. Introduction

The National Olympiad in Informatics (NOI) serves as a significant platform for students in Sri Lanka to cultivate their skills in computer science and programming. The competition aims to promote the development of theoretical knowledge, programming proficiency, and logical, critical, and creative thinking among students. Through the identification of exceptional participants, the competition facilitates the advancement of computer science education, raises awareness among secondary school students and teachers, and ultimately selects a national team to represent Sri Lanka at the International Olympiad in Informatics (IOI).

The National Olympiad in Informatics (NOI) was established in 1992 with the aim of providing a platform for Sri Lankan students to enhance their theoretical knowledge and programming skills in computer science. Despite its initial success, the program faced various challenges in management and organization, which led to stagnation in its progress. However, in 2018, a group of IOI Informatics Olympiad Alumni took the initiative to revive the program. Since then, the organizers of the NOI have been working tirelessly to improve the quality of the program year by year, making it one of the foremost olympiads in Sri Lanka. The Ministry of Education in Sri Lanka has also endorsed the competition, recognizing its importance in promoting computer science education and identifying exceptional students in the field. The competition includes

training rounds, a screening round, a national round, and a training camp for the top performers, with one-on-one discussions available to resolve any issues encountered during the process.

The competition consists of several rounds, including training rounds, a screening round, a national round, and a training camp for the highest-performing participants. In addition, the organizing committee provides opportunities for one-on-one discussions between students and mentors to address any issues encountered during the competition. These initiatives provide a comprehensive platform for students to hone their skills and gain valuable experience.

The remainder of this country report is organized as follows: in Section 2 the organizational structure of the NOI is discussed; in Section 3 the program structure of the NOI is discussed; in Section 4 the performance of the Sri Lankan Delegation at the IOI is discussed; in Section 5 the syllabus followed at the competition is discussed; the Section 6 discusses how the NOI was conducted during the COVID-19 pandemic; the Section 7 concludes the report and Section 8 provides the acknowledgments

2. Organizational Structure of the NOI

The NOI organization is a part of the ACM Student Chapter of UCSC managed under the University of Colombo School of Computing (UCSC). The NOI organization has 3 distinct sections, namely, (i) EAC – The Executive Advisory Committee, (ii) SC – The Scientific Committee, (iii) OC – The Organizing Committee as shown in the Fig. 1.

2.1. *Executive Advisory Committee*

The EAC is composed of the academic staff members of the University of Colombo School of Computing (UCSC). The Director of the UCSC acts as the Patron of the NOI program and the Faculty Advisor of the ACM Student Chapter of UCSC also

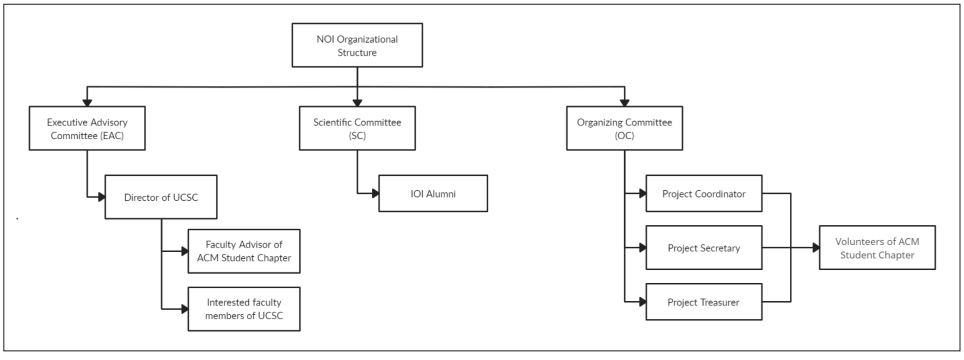

Fig. 1. Organizational Structure of the NOI.

acts as the Faculty Advisor for the NOI program. Additionally, the previous faculty sponsors and staff members of the UCSC who are interested in the program are part of the EAC.

2.2. *Organizing Committee*

The OC is responsible for organizing the entire NOI program. It includes volunteers from the ACM Student Chapter of UCSC and there are 3 major positions within the OC.

- Project Coordinator – Responsible for the entire NOI program.
- Project Secretary – Responsible for the operational activities.
- Project Treasurer – Responsible for the financial activities.

The coordinator, secretary and treasurer are appointed by the Executive Committee of the ACM Student Chapter of UCSC.

The team leader and the deputy leader for the Sri Lankan delegation for the International Olympiad in Informatics (IOI) are appointed from the Scientific Committee and the Organizing Committee, one from each section. In case the team leader is selected from the SC, the deputy leader will be selected from the OC, and vice versa.

2.3. *The University of Colombo School of Computing*

In response to the rapid development and evolving nature of the Information Technology field, coupled with anticipated structural changes, there arose an urgent need for a higher education institution dedicated to computing in Sri Lanka. In 2002, Vidya Jyothi Professor V. K. Samaranayake founded the University of Colombo School of Computing (UCSC) with the objective of establishing such an institution.

Since its inception, the UCSC has established a distinguished reputation as the foremost higher education institution for computing in Sri Lanka. Its primary objective is to equip students with the necessary knowledge and skills to pursue careers in Information and Communication Technology, such as Software Developers, Systems Analysts, Network Administrators, Database Administrators, Web Developers, IT Managers, IT Strategic Planners, and IT Policy Makers.

3. Program Structure of the NOI

The NOI Sri Lanka program's structure has 3 stages (as shown in Fig. 2);

(i) Monthly practice contests.
(ii) Online qualifier round.
(iii) The National Olympiad in Informatics.

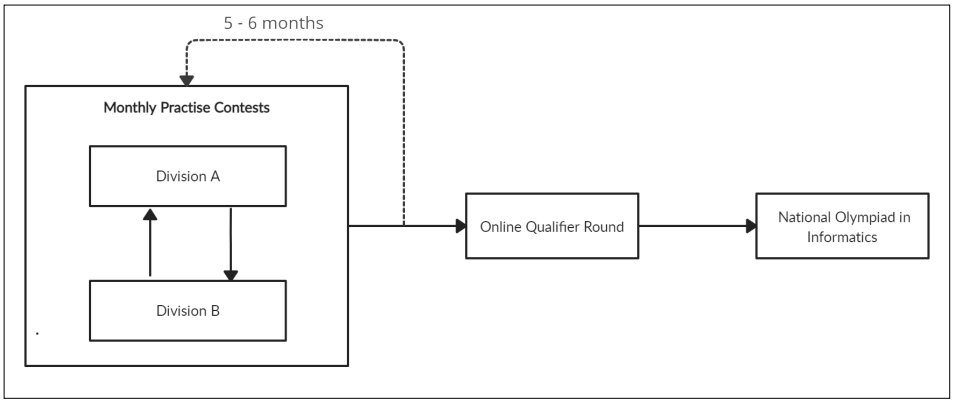

Fig. 2. Program Structure of the NOI.

3.1. *Monthly Practise Contests*

The NOI program starts with the monthly practice contests. The participating students will be split into Division A and Division B, and separate monthly contests will be hosted for each of them. Students who are interested in participating in the NOI program are required to create an account at `https://www.noi.lk`. Once the registration is completed, the students will have access to the NOI Portal (`https://portal.noi.lk/`), which is the Learning Management System (LMS) of the NOI program. All the announcements, contests and other material related to NOI Sri Lanka will be published on the aforementioned LMS.

3.1.1. *Division A*

Each year, Division A begins with the eight participants who had the highest scores during the NOI program the year before (Wang *et al.*, 2010). Participants who enter this division will remain until the end of the next Division B monthly practice contest. Every month, the participants will be required to take part in a particular set of programming contests that the Scientific Committee determines. The contests are chosen from CodeForces[1], AtCoder[2] and CodeChef[3]. In most cases, there will be 4 contests each month. The score of the participants in the division A program will be calculated based on the score obtained by participating in the aforementioned contests by the Scientific Committee and the participants will be ranked accordingly. At the end of each month, the last ranking two members of Division A will be demoted to Division B.

Contestants in the division A program are allowed to compete in Division B monthly contests, but their results will not be considered for the final leaderboard of the Division B contest.

[1] Available: `https://codeforces.com/`

[2] Available: `https://atcoder.jp/`

[3] Available: `https://www.codechef.com/`

3.1.2. *Division B*

Apart from the Division A participants, every other participant will be included in Division B. Contestants in this division have to face separate monthly practice contests hosted by the ACM Student Chapter of UCSC in collaboration with the Scientific Committee of the NOI. At the end of each Division B monthly contest, the top two contestants of the Division B program will be promoted to the Division A program.

The monthly contests will continue for about 5 months depending on the timeline of the International Olympiad in Informatics (IOI).

3.2. *Online Qualifier Round*

The online qualifier round serves as a screening test to select the topmost participants of the large participant pool of Division B of the NOI. The competition is open to all primary and secondary school students in Sri Lanka who are younger than 20 years. The contest will be hosted on HackerRank[4] by the ACM Student Chapter of UCSC. In previous years, the qualifier round was held as a 5-hour contest where the participants were asked to be present at the UCSC. However, due to logistical challenges and travel challenges, the competition was switched to a virtual mode. During the COVID-19 pandemic, the online qualifier was held as a 5-hour online contest with virtual proctoring but later in 2022, the contest was switched to a 12-hour virtual contest where the participants were given 6 problems to solve.

The student submissions were manually checked for plagiarism by the Scientific Committee and volunteers from the ACM Student Chapter of UCSC. Only the students with at least one valid submission were issued a certificate of participation. The top 8 participants with the highest scores were selected to compete in the National Olympiad in Informatics contest (also known as the final round). In addition to the 8 participants from the qualifier round, the 8 students who remained in Division A after the final practice contest will be competing in the National Olympiad in Informatics. Altogether, 16 students will be participating in the National Olympiad in Informatics.

3.3. *The National Olympiad in Informatics*

The National Olympiad in Informatics is a similar contest to the International Olympiad in Informatics (IOI). The contest will run for 2 days and contestants will receive 3 problems to solve each day within a 5-hour time block. As similar to the previous contests, the problems will be set by the Scientific Committee in collaboration with the Informatics Olympiad alumni. The 4 students who score the highest marks in this competition and who satisfy the eligibility criteria of the IOI will be representing Sri Lanka at the International Olympiad in Informatics (IOI).

[4] Available: `https://www.hackerrank.com/`

3.3.1. *Awards*

Considering the scores of the National Olympiad in Informatics, the following awards will be awarded. Unlike the competition, the medals are awarded according to two age groups to motivate and increase the participation of younger students.

- The IOI Sri Lankan delegation – Awarded to the 4 students who score the highest in the National Olympiad in Informatics and get selected to the Sri Lankan delegation for the International Olympiad in Informatics (IOI).
- Under 16 age category:
  - Gold – Awarded to the student with the highest score in the under-16 age category.
  - Silver – Awarded to the student with the second-highest score in the under-16 age category.
  - Bronze – Awarded to the student with the third highest score in the under-16 age category.
- Under 20 age category:
  - Gold – Awarded to the student with the highest score in the under-20 age category.
  - Silver – Awarded to the student with the second-highest score in the under 20 age category.
  - Bronze – Awarded to the student with the third highest score in the under-20 age category.
- Special Awards:
  - Best Performing Contestant – Awarded to the student with the highest score regardless of the age category.
  - Best Performing School – Awarded to the school that has the highest count of students among the finalists who participated in the final round, and have achieved a score that is greater than the median.
  - Best Performing Girl Coder – Awarded to the female participant with the highest score regardless of the age category to encourage female participants to take part in the contest.

The awards ceremony will be held after the Sri Lankan delegation returns home from the International Olympiad in Informatics (IOI).

4. Performance of the Sri Lankan Delegation

The following section will discuss the performance of the Sri Lankan delegation at the International Olympiad in Informatics (IOI) over the past 5 years.

According to the performance statistics from the International Olympiad in Informatics-Statistics[5], after the revival of the competition in 2018, a steady improvement could be observed in the IOI Team Performance. The IOI Team Performance shown

[5] Available: `https://stats.ioinformatics.org/`

in Fig. 4 is calculated by averaging the sum of each contestant's average marks as follows.

$$contestant\_average = \frac{marks\_obtained\_by\_contestant}{total\_marks} * 100\%$$

$$IOI\_team\_performance = \frac{\Sigma\ contestant\_avaerage}{number\ of\ contestants}$$

It could be observed from Fig. 3 that the IOI Team Performance declined with the collapse of the NOI but after the revival of the program, the team is observed to be making steady progress as depicted in Fig. 4. Also, it could be observed as shown in Fig. 4,

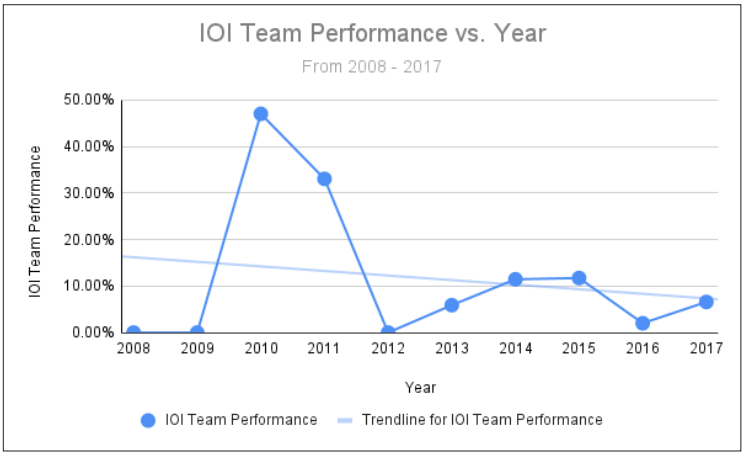

Fig. 3. IOI Sri Lanka Team Performance from years 2008 to 2017.

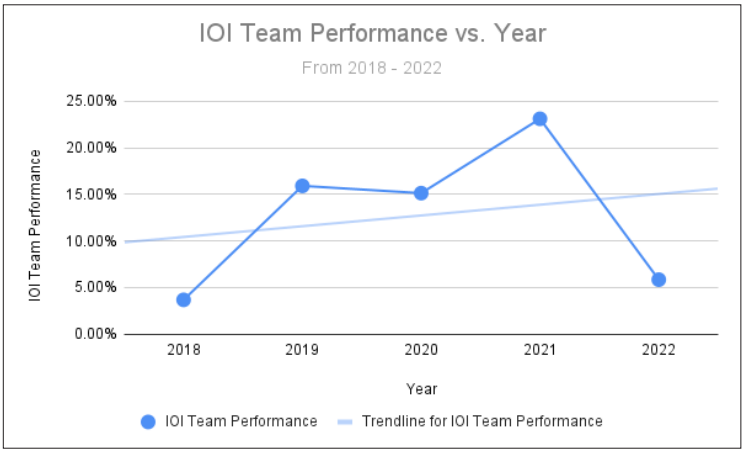

Fig. 4. IOI Sri Lanka Team Performance from years 2018 to 2022.

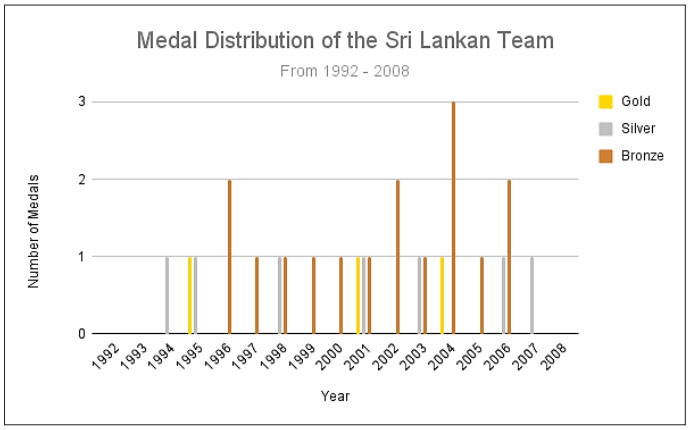

Fig. 5. Medal Distribution of the Sri Lankan Team.

the Sri Lankan Team saw a commendable improvement in IOI 2021 but it declined drastically in IOI 2022. The Scientific Committee is working on identifying probable causes and taking measures to improve the performance of the team in IOI 2023.

As seen in Fig. 5 from 1994 up until 2007, the Sri Lankan team has been able to win medals consistently[6]. However, due to the collapse of the program, for nearly 10 years, the team was not able to win any medals. After the revival of the program in 2018, the team came close to winning a medal but missed by just 5 points in IOI 2021[7].

5. Syllabus and the Tasks

A syllabus is important as a guide for the problem setters of NOI and for making sure that the relevant competencies expected of the contestants are covered properly. The syllabus of each year's NOI program is compiled at the beginning of the program by the aforementioned Scientific Committee to make sure all the competencies are covered at the monthly practice contests, online qualifier round and the NOI. It is compiled by considering the IOI Syllabus[8] and past IOI questions[9].

The following outlines the syllabus that was used in the National Olympiad in Informatics 2022:

- Graphs and Trees
  - Shortest Path
  - Connected Component/ Disjoint Set
  - Directed Acyclic Graph
  - Minimum Spanning Tree

[6] Available: https://stats.ioinformatics.org/results/LKA
[7] Available: https://stats.ioinformatics.org/results/2021
[8] Available: https://ioinformatics.org/page/syllabus/12
[9] Available: https://ioinformatics.org/page/contests/10

- Algorithmic Strategies
- Greedy Algorithm
  - Brute Force Algorithm/ Implementation
  - Divide and Conquer
    - Dynamic Programming
    - Recursion
  - Backtracking
- Binary Search
- Two Pointers
- Ad-hoc
- String Algorithm
  - Substring
- Bitmask/Boolean algebra
- Combinatorics
  - Inclusion/exclusion
  - Pigeon Hole
  - Pascal's Identity
  - Binomial Theorem/Coefficients
- Data Structures
  - Binary Indexed Tree
  - Segment Tree
  - Stacks
  - Heap
  - Trie
- Miscellaneous:
  - Covers any other topic that is not included in the aforementioned syllabus

Throughout the program, all the above were covered in varying difficulty levels from easy, medium to hard as seen fit by the Scientific Committee.

5.1. *Sample Tasks*

The sample tasks can be demonstrated under 3 categories considering the program structure of the NOI program; (i) Monthly contests (ii) Qualifier round (iii) NOI final round.

5.2. *Monthly Contest Problems*

COVID-21 Variant: The problem involves analyzing interactions between people in a room to determine if there is at least one person who, if infected, would spread the disease to the entire room. The interactions are recorded without timestamps. The spreading behavior is influenced by age and distance. The goal is to determine if COVID-19 and COVID-21 variants would spread to the whole room based on the given interactions. The input consists of the number of test cases, the number of people, the number of

interactions, the age of each person, and the distances between interacting people. The output should indicate whether COVID-19 and COVID-21 would spread to the whole room for each test case (Armoni *et al*., 2006).

33.33% of contestants who attempted this question obtained full marks.

Topic(s): Graph (MST), Contest: Monthly contest – April 2021.

Palindromic Substring Discovery: The task is to find the largest substring within a given string that can be rearranged to form a palindrome. The goal is to determine the maximum length of such a substring.

33.33% of the contestants who attempted obtained full marks for this problem.

Topic(s): Bitmask, Dynamic Programming, Contest: Monthly contest – January 2021.

5.3. *Qualifier Round Problems*

Petrol Queue: The task is to rearrange the distribution of items in an array in non-increasing order. The input consists of an array representing the initial distribution, and the goal is to determine the minimum number of operations required to achieve a non-increasing order. At each operation, two adjacent positions can be selected to perform a transformation. The possible transformations involve removing an item from one position and adding it to the adjacent position, or vice versa. The output should be a single integer representing the minimum number of operations needed.

A comprehensive solution has not been proposed by the candidates, and the maximum score achieved was 81.08%.

Topic(s): Dynamic Programming, Contest: Qualifier round 2022.

Building the artifact: The task is to determine if it is possible to build an artifact by collecting interconnected parts. The input consists of the number of parts and their connections, where each connection indicates that one part must be collected before another. However, some parts may have a self-connection, making them impossible to collect. The goal is to output "YES" if it is possible to build the artifact, and "NO" if it is not possible.

6.98% of the contestants who attempted have obtained full marks.

Topic(s): Topological sort, Contest: Qualifier round 2021.

5.4. *Final Round Problems*

Mouse in the Exploding Maze: The task is to calculate the minimum time to traverse a 2D grid (R rows x C columns) from a starting cell to an exit cell. The grid contains free cells, blocked cells, or cells with a toggling obstacle that alternates between accessible and inaccessible every minute. Movement is allowed to an adjacent cell (up, right, down, left) or to remain stationary each minute. The starting and exit cells are always free.

4.17% of the contestants who attempted obtained full marks for this problem.

Topic(s): Graph traversal, Contest: Final round 2019.

Eat Your Peanuts: The task is to assign N contiguous segments, each containing a specific quantity, among a set of F recipients in a way that minimizes the maximum total quantity allocated to any single recipient. Each recipient should be given one or more adjacent segments, and all segments must be assigned. The program should output a single integer, representing the maximum total quantity received by any single recipient under the optimal assignment.

A comprehensive solution has not been proposed by the candidates, and the maximum score achieved was 54.02%.

Topic(s): Binary search, Contest: Final round 2019.

Find the Worlds: The task is to analyze a set of points representing cities in a 2D universe, with each city located at a unique integer coordinate (x, y). Cities are grouped into distinct worlds such that the euclidean distance between any two cities within a single world is ≤10,000, and the distance between any two cities from different worlds is >10,000. The program should determine and output the number of worlds and the number of cities within each world.

A comprehensive solution has not been proposed by the candidates, and the maximum score achieved was 95%.

Topic(s): Ad-hoc, Hashing, Contest: Final round 2020.

6. Effects of the COVID-19 Pandemic

The COVID-19 pandemic has resulted in significant disruptions to educational institutions and their operations worldwide. Social distancing and other public health measures necessitated the closure or transition to remote learning for many schools and universities. The National Olympiad in Informatics has been affected by the pandemic in terms of logistics, organization, student participation, and performance. In light of all the issues associated with public health concerns, the Organizing Committee has made the decision to conduct the contest entirely online (Dhawan, 2020).

6.1. *Early Efforts*

During the initial stages of the COVID-19 pandemic, the National Olympiad in Informatics (NOI) related contests were conducted virtually using Zoom[10] video conferencing software for supervision. The participants were grouped and assigned a proctor, who was typically a volunteer recruited from the University of Colombo School of Computing (UCSC). Each group was allocated a Zoom breakout room and instructed to activate their web cameras, enabling the proctor to monitor their participation.

Despite the Organizing Committee's efforts, instances of cheating by contestants were discovered during the virtual National Olympiad in Informatics (Arkorful et

[10] Available: `https://www.zoom.us/`

al., 2015). Moreover, other issues such as a lack of computer devices resulting from low family income and inadequate connectivity infrastructure in rural areas affected some students. In response to these challenges, the OC devised an innovative solution aimed at ensuring the contest's integrity and ensuring inclusivity across diverse student backgrounds.

6.2. *The NOI Virtual Proctor*

The NOI Virtual Proctor is a simple web-based tool where it provides students with a safe exam environment to participate in the National Olympiad in Informatics contests. The students were onboarded into the platform with their registration details and they were informed of their respective credentials before the contest.

National Olympiad in Informatics Virtual Proctor required initial permission to access the web camera and to screen record in order to capture the student's environment during the initial sign-in. After unlocking the contest at the start time, the tool monitored the student's browser tabs to verify that only authorized pages were accessed. The allowed web pages were pre-configured into the platform by the OC, and in this instance, only the C++ manual and the Hackerrank[11] contest were permitted.

In the event of an unauthorized tab being opened, no warning was given to the student, but the incident was immediately reported to a Slack[12] channel, which contest officials monitored throughout the contest. The tool periodically captured the candidate's screen and uploaded it to cloud storage in the form of 2-minute chunks. In cases of connectivity issues, the tool cached the video chunks and incident reports on the local machine and synced them with the cloud once the connection was re-established.

National Olympiad in Informatics Virtual Proctor significantly aided in the management of the contest and in minimizing attempts of cheating during the NOI.

The same group of organizers who developed the National Olympiad in Informatics Virtual Proctor tool further developed it into a commercial-grade product capable of accommodating online evaluations on a larger scale, globally. Additional information on this tool can be found via the following link: `https://proktara.com`. This development serves as a testament to the innovation and adaptability of the NOI Organizing Committee in response to the challenges presented by the COVID-19 pandemic.

Students who faced difficulties in obtaining the necessary equipment to compete in the NOI were provided with an online form to inform contest officials of their situation. The OC took necessary measures to accommodate the students who responded, including providing equipment such as laptops and internet routers. Volunteers from the UCSC were dispatched to the students' locations with the necessary equipment and to monitor them throughout the contest, while strictly adhering to the health guidelines imposed by the Sri Lankan government. This initiative ensured that all students, regardless of their backgrounds, were given equal opportunities to participate in the contest.

[11] Available: `https://www.hackerrank.com/`

[12] Available: `https://slack.com/`

7. Conclusion

It could be observed that after the revival of the National Olympiad in Informatics competition in 2018, the quality of the competition has been improving year by year. Unprecedented challenges such as the COVID-19 pandemic and financial instabilities in Sri Lanka did not hinder the progress of the competition. Identifying strengths and weaknesses after each year's competition and taking a course of action that further increases the strengths and overcomes weaknesses has been vital in increasing the impact of the competition.

In conclusion, the NOI competition can have a significant impact on the education system and students of Sri Lanka. It provides an opportunity for exceptional students to showcase their programming skills and compete with peers from all around the country. Garcia-Mateos (Garcia-Mateos and Fernandez-Aleman, 2009) and Dagienė (Dagienė, 2010) have noted the influence of programming, and informatics olympiads in studying computer science. Thereby, participating in the NOI can inspire students to pursue higher education and professional careers in Computer Science and related disciplines, consequently raising the standard of Computer Science education in Sri Lanka.

8. Acknowledgements

We would like to express our gratitude to all those who have contributed to the successful completion of the National Olympiad in Informatics (NOI). First and foremost, we would like to thank the Ministry of Education – Sri Lanka and the University of Colombo School of Computing (UCSC) for unwavering support and guidance throughout the entire NOI program.

We would also like to extend our sincere gratitude to the ACM Student Chapter of University of Colombo School of Computing and all the volunteers who generously gave their time and effort to the NOI program. Without their willingness to share their talents and expertise, the NOI program would not have been a success.

Furthermore, we are grateful to the Informatics Olympiad alumni, our colleagues and our friends who provided us with their encouragement and assistance in various aspects of the NOI. Their contributions, no matter how small, have been significant in helping us navigate the challenges of conducting a successful NOI program.

Lastly, we acknowledge the financial support provided by all the institutes, which enabled us to carry out the NOI. We are deeply appreciative of their investment in this program and the opportunities it has provided us.

We recognize that there are many others who have contributed to the National Olympiad in Informatics in one way or another, and we apologize for any unintentional omission. Nevertheless, we are grateful for everyone who has supported us in this endeavor.

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