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Results of the International Student Olympiads in Physics as a Reflection of the Demand for Physical and Mathematical Education in Countries

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ABSTRACT
The aim of the study is to establish a link between the level of achievement of teams in the International Physical Olympiads and the attention of the respective countries to the development of physical and mathematical education. The research was carried out on the basis of generalization and analysis of the collected original material and based on the accumulated experience of scientific and pedagogical work with gifted youth in physics. As a result of the research, the collected generalized and systematized information is presented in a form that clearly represents the level of achievements of the teams of the world's leading countries at the International Physical Olympiads of different years. The list of countries whose teams consistently achieve high results has been clarified. The most significant and stable were the results of teams from mainly Asian countries, including China, South Korea, Taiwan, Singapore, India, Thailand, Vietnam, as well as Russia and the United States. It is determined that the ratings of national teams on the results of competitions for a long time remain almost unchanged. For the first time, it has been clearly shown that the level and stability of the successes achieved by the teams at the International Physical Olympiads are determined by the attitude of the respective states to the development of science and education. It is concluded that any outstanding achievements are based on three prerequisites: the availability of appropriate abilities, motivation and ability to implement the planned. Fulfillment of the above prerequisites for physical and mathematical education in countries whose teams have proved to be stable leaders of the International Physical Olympiads has led to the achievement of appropriate results and gaining worldwide recognition and respect.
***Keywords**: International Physics Olympiad, achievements, motivation, students, education, science, team, count*

1. INTRODUCTION

The authors of this study have long been working professionally with gifted young people in physics. In particular, they teach and purposefully prepare physically capable students for various competitions in physics - Olympiads, tournaments, competitions of scientific reports, etc. Also, one of the authors as the leader of student teams from Ukraine participated in the International Physics Olympiads (hereinafter IPhO) 1996 - 2019, which allowed accumulating a huge amount of information and experience in working with talented young people in physics in Ukraine and the world.

Basically, studies, which are related to International Physical Olympiads, investigate gender differences, students' abilities to solve the problems, general statistic changes in results or complexity of tasks. In this study, authors try to find correlation between Olympiad results and national educational strategies.

Accordingly, based on the original collected material and experience of scientific and pedagogical work, the authors of this study sought to qualitatively clarify the relationship between the formal results obtained by teams around the world on IPhO of different years and the attention of relevant countries to the development of physical education.

2. METHODS

This study uses the method of generalization, comparison and analysis of selected and long-term accumulated data on the results of the International Physical Olympiads. Data and information for analysis were collected from the relevant literature as well as a result of the personal participation of one of the authors in more than twenty IPhOs and on the basis of long experience of the authors

with gifted youth in physics. The purpose of the study was:

1. Investigate and summarize the achievements of the teams of the countries that receive the highest number of IPhO awards each year.
2. Find out the list of countries whose teams consistently win the highest number of top IPhO awards.
3. To study the features and dynamics of change during the last decades of the list of countries whose teams perform best.
4. Analyze the ways, methods, and "secrets" of achieving outstanding results.

3. RESULT AND DISCUSSION

3.1. Olympiad results by years

The International Physics Olympiads was started in 1967 by Poland, following the example of the International Mathematical Olympiads, which have existed since 1959. It was at this time in most countries of the world came a period of extraordinary rise in the prestige of scientific and technological activities. Accordingly, the educational sector was developing intensively, competitions for universities and institutes for physical-mathematical and physical-technical specialties at that time were the highest. Moreover, this trend was equally observed regardless of the political and economic system of the countries. At the same time, it should be noted that at the time of launching the IPhO, China, Korea, Singapore, India, Thailand and some other countries in the Asian region were not mentioned as countries with developed scientific and technological potential. Therefore, the results of IPhO in recent decades, which we present below, in our opinion are very interesting, revealing and worthy of in-depth comprehensive analysis.

Initially, IPhOs were held every two years, and then annually. Accordingly, 50 Olympiads have been held so far, and the history of their formation, development, scientific content and results largely reflect the world trends in the development of the physical and technical field of science and relevant educational areas.

One of the fundamental positions of the IPhO community has always been and remains the desire to avoid conflicts on any grounds, and discussions should focus only on scientific issues. Accordingly, the IPhO statute stipulates that the team place of each country is not determined by the results of the competition. This is due, firstly, to the fact that IPhO is an individual, not a team type of competition, and secondly, the desire to avoid a direct comparison of the achievements of individual teams. To this end, the statute stipulates that the results of all participants who have not won the official awards of the Olympiad are considered secret and not disclosed, but remain known only to those participants who have won them.

In the study, the authors, respecting the existing restrictions and not violating them, based on the official results of the competition, analyzed them and made appropriate conclusions. In order to make it possible to compare the results achieved by teams around the world, we used an informal but well-recognized approach to calculating results, namely, the teams scored points as follows: gold medal - 5 points, silver - 3 points, bronze - 1 point.

In the table we present the results of the performances of the best student teams in the world at IPhO 2009 - 2019 [1 - 11].

Table 1. IPhO Results in 2009-2019

Place (rating) of the country	Country whose team participated in the IPhO competition (2009–2019)	Number of gold medals won	Number of silver medals won	Number of bronze medals won	Total medals won	Total points were awarded
1.	China	55	-	-	55	275
2-3.	South Korea	46	7	2	55	253
2-3.	Taiwan	44	11	-	55	253
4.	Russia	36	17	2	55	233
5.	Singapore	33	21	1	55	229
6.	USA	30	23	2	55	221
7-8.	India	26	26	3	55	211
7-8.	Thailand	26	26	3	55	211
9.	Vietnam	23	23	9	55	193
10.	Romania	19	26	10	55	183
11.	Japan	15	27	12	54	168
12.	Hong Kong	14	28	13	55	167
13.	Israel	10	31	13	54	166
14.	Germany	7	31	14	52	142
15-16.	Indonesia	13	19	17	49	139
15-16.	Hungary	9	25	19	53	139

17.	Iran*	9	27	12	48	138
18.	Kazakhstan	11	23	13	47	137
19.	Ukraine	3	33	18	54	132
20.	Turkey	4	31	18	53	131
21.	France	3	31	18	52	126
22.	Belarus	7	20	23	50	118
23.	United Kingdom	3	23	29	55	113
24.	Serbia	3	19	29	51	101
25.	Bulgaria	2	18	30	50	94
26.	Slovakia	5	14	25	44	92
27.	Czech Republic	1	18	27	46	86
28.	Poland	5	11	26	42	84
29.	Canada	1	15	27	43	77
30.	Estonia	4	12	12	28	68
31.	Australia	1	8	32	41	61
32.	Austria	1	8	24	33	53

*****In 2019, the Iranian team did not participate in the competition, because that year the IPhO was held in Israel.

Note that IPhO also has a certain "intermediate" type of awards - Honorable Mentions, which is widely used to celebrate other participants, but these awards have not gained much prestige and therefore in our study we did not pay much attention to them.

3.2. Winners rating methodology

We ranked the countries by the amount of points scored, although we must admit that this approach is not exhaustive because, for example, for a certain year, one team can score 5 points, winning only one gold medal (four more team members were left without medals). At the same time, another team in the same Olympiad can also score 5 rating points by winning five bronze medals. Such cases, in particular, have occurred. Which is "better" - one gold, i.e. the highest award, or five more modest awards - is a very controversial issue and may well be the subject of a separate study. A gold medal unequivocally indicates the highest level of achievement of a particular student, at the same time, because other team members were insufficiently prepared and did not win awards; such a result indicates personal talent, determination, efficiency and other positive qualities of a particular medallist competitions and the quality of functioning of the system of work with gifted youth in general. On the other hand, if all members of one team demonstrate, although not the highest, but quite high and approximately the same level of achievement (which happens in practice), in our opinion, this is in addition to high abilities of students, primarily indicates high quality selection and availability diverse systematic preparation of students for competitions.

Also a "problematic" point of comparison of participants' achievements is that medals of the same grade can be awarded to participants within certain limits of their results. That means personal achievements of participants awarded medals of the same grade may be somewhat different. But it does not make sense to compare the achievements of teams by the number of points given to the participants by the jury members, because firstly, this information is not officially published anywhere and is known to a very limited number of people, and secondly there are "bad" cases when almost every member of a team did not have enough points to win a medal, respectively, members of such a team do not receive medals. But the number of points awarded to the jury, the results of such a team may exceed the results of teams, some members of which "barely" succeeded cross the point border, get the appropriate medals and be credited for achievements.

Despite certain nuances of possible summarizing options, it is undeniable that the "smallest" award of international competitions of this level, a priori, is evidence of outstanding achievements.

In any case, the number and quality of awards won by teams over more than a decade, despite the possible individual fluctuations in the results, convincingly and clearly show the level of training of the respective teams and the stability of their performances.

3.3. Dependence between results and national educational strategies

It is a recognized fact that over the past few decades, a number of countries (mostly in the Asian region) have experienced a period of rapid industrial, scientific and cultural development. As a result, with long-recognized leaders as the United States, Japan, Germany and Russia countries such as China, South Korea, Taiwan, Singapore, India, Thailand, Hong Kong, and Indonesia and some other have joined the ranks. That objectively led to an increase in the level of science and, accordingly, the level and prestige of education in these countries. In general, there is an obvious trend of growing interest of Asian countries in the development of basic sciences, science-intensive technologies and paying great attention to the

creation of intellectual potential, i.e. quality and mass education of young people.

The high level of achievements of the best teams on IPhO (presented in the table below) is both a consequence of thoughtful and far-sighted educational policy of the respective states and evidence of the demand for relevant intellectual activity. After all, as the experience of our many years of scientific and pedagogical practice shows, any outstanding achievements are based on three prerequisites: the availability of appropriate abilities, motivation, which in turn is determined by the relevant need or interest and the ability to implement the planned. It should be noted that the possibility of implementing the planned contains at least two aspects: the ability to study (get the appropriate education) and the ability to find appropriate application of acquired knowledge and skills, i.e. relevant activities should be in demand by society.

Fulfillment of all the above prerequisites for physical and mathematical education in countries whose teams have proved to be stable leaders of IPhO has led to the achievement of appropriate results and gaining worldwide recognition and respect.

Despite the fact that the number of IPhO member teams has increased over the last decade to more than eighty, the number of countries all members of which consistently win medals is actually limited to ten or eleven, and the number of countries whose teams score at least a quarter of the number of points scored by the leader team is about a third of the number of participating teams. In other words, there is a small group of countries whose teams are stable leaders of IPhO competitions, there is also a group of countries whose team members systematically win a large number of medals of various kinds and, at the same time, there is a fairly stable and significant group of teams whose members remain without IPhO medals. We have focused our attention on a thorough and comprehensive study of the components, conditions, and causes that underlie such group divisions of countries.

The content and scientific level of IPhO tasks are determined by the jury and the international committee, which includes all the leaders of the participating teams. This maintains a proper balance of requirements, scope, thematic focus and style of task formulation, and so on. Normal is the highest personal achievements of the absolute winners of the competition at the level of approximately 47 - 49 points, despite the fact that the possible maximum of achievements is 50 points. The level (limits) of gold, silver and bronze awards are determined by a special algorithm annually, depending on the level of achievement of all IPhO participants in the year. At the same time, unfortunately, recently there has been a tendency to reduce the average values of points that ensure the receipt of medals, but this aspect of the problem, we consider the subject of a separate study.

It should be noted that recognizing the generally positive dynamics of development of science-intensive industries, the world is increasingly showing a tendency to reduce interest in studying basic sciences in favor of the most talented young people to apply information and communication technologies and master sciences that give repayment of the amount of spent mental effort and money, which unfortunately in some way has a negative impact on the level of international competitions in physics in general. Because physics has certainly been and remains an experimental science, which on the one hand makes it extremely interesting and attractive, on the other hand any activity related to physics is very expensive, complex, long and science-intensive with, as a rule, delayed getting results. All this against the background of intensive development of other modern and less expensive branches of knowledge reduces the attractiveness of physics and causes a corresponding outflow of gifted youth, which in turn does not contribute to the development of physical science in general.

Carrying out competitions in physics, as well as teaching physics in general, is quite expensive, and education and training of students are long and require highly qualified personnel, developed facilities, original equipment, consumables and more. According to IPhO results, international physics competitions are led by teams that not only consist of naturally gifted young people, but also have the opportunity for a long time to purposefully select and prepare participants for the competition, investing considerable funds in this activity.

In these conditions, the national educational policy and the attitude of each country to the development of basic sciences, including physics, and the formation and development of the intellectual potential of the nation becomes extremely important. The global understanding that the development of modern information and other high-profit technologies is based on the achievements of basic sciences also plays an important role.

The IPhO results, of course, are not an unambiguous and complete reflection of the state and level of educational and scientific activities in the respective country. But comparing the achievements of the Olympiad participants with what is known about the level and attitude to science and education in the respective states; it is possible to note the presence of at least strong indirect links between them.

By the way, we are also interested in the fact that the rating of national teams according to the results of IPhO competitions 2009 - 2014 and 2009 - 2019 at the qualitative level remain almost unchanged, which once again shows that the observed trends, approaches and their consequences in general remain fairly stable.

4. CONCLUSION

1. As a result of generalization and systematization of the collected information, it is presented in a form that clearly represents the level of achievements of the teams of the world's leading countries on IPhO for the last eleven years.

2. The list of countries whose teams consistently achieve high results is clarified. The most significant and stable were the results of teams mainly from the Asian region, which is in line with the trends of recent decades for rapid scientific, technological and economic development of a number of Asian countries, including China, South Korea,

Taiwan, Singapore, India, Thailand and Vietnam. Russia and the United States are also among the permanent leaders.
3. At the qualitative level, it is determined that the ratings of national teams on the results of competitions for a long time (decades) remain almost unchanged, which once again shows that the observed trends, approaches and their consequences in general remain fairly stable.
4. For the first time, it has been clearly shown that the level and stability of the achievements of IPhO teams are determined by the attitude of the respective states to the development of science and education. Any outstanding achievement is based on three prerequisites: the availability of appropriate abilities, motivation, which in turn is determined by the relevant need or interest, and the ability to implement the planned. Fulfillment of the above prerequisites for physical and mathematical education in countries whose teams have proved to be stable leaders of IPhO has led to the achievement of appropriate results and gaining worldwide recognition and respect.

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