

# Olympiads in Informatics as a Mechanism of Training World-Class Professionals in ICT

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**Abstract.** The development of information technologies has not brought only positive aspects to the society, but also negative ones: youth isolation, Internet addiction, inability to express thoughts logically, poor physical health, etc. Such problems impede the process of youth development and making professionals of them. But Olympiads in Informatics and Programming can turn the teens' obsession with computers and the Internet into huge advantage that will be very beneficial in future. The research undertaken analysed the role of Olympiads in Informatics and Programming and proved that Olympiads are effective mechanisms of investments into youth. The research covered about 300 students of Computer Technology Chair of ITMO University (St. Petersburg National Research University of Information Technologies, Mechanics and Optics) and the latest data on the factors motivating students were received. In particular, that there is interconnection between Olympiads and students' motivation in acquiring the profession; that Olympiads contribute to the effective development of youth; and that they provide opportunity to get a good education that will bring financial prosperity, career satisfaction and self-realization.

**Keywords:** informatics, system of olympiads, olympiads in informatics, ICT education.

## 1. Olympiads from Early Age to Present Time

Olympiads have a long and colourful history. The first written records of the ancient Olympic Games are traced back to 776 BC in ancient Olympia (Greece). They were devised to measure physical strength, agility and stamina and existed for nearly twelve centuries until 393 A.D. when they were banned by Emperor Theodosius. The first modern Olympiads took place in 1896 in Athens. Since then they have acquired different forms and may assess different abilities, skills and aptitudes.

With the development of human society, mental labour substitution for physical one and at last the change of priorities from physical to mental labour in human minds, there were offered competitions which measured knowledge, mental & creative abilities, the ability of long-concentrated mental activity or mental performance – Olympiads in Sci-

ence. The first international Olympiad in Science appeared in 1959. It was Olympiad in Mathematics (IMO), being held annually since that time. A decade later there appeared Olympiads in Physics (1967) and Chemistry (1968). The advent of personal computers in the 80-s and their proliferation into mass audience gave rise to the development of Informatics and Programming in schools and universities which brought about the establishment of International Olympiads in Informatics (IOI) in 1989.

## 2. The Development of ICT in the Information Age

Since the emergence of the first Olympiad in Science, a lot of other subject-specific Olympiads have come into play – Olympiads in Biology, Astronomy, Astrophysics, and even Medicine. But Olympiads in Informatics (programming) still remain one of the most important, which explains the emergence of Olympiads or Challenge for the youngsters, such as “Bebras” – International Challenge on Informatics and Computational Thinking (Pozdniakov *et al.*, 2016), ([bebras.org](http://bebras.org)). One may hear a lot about Information age (also known as the Computer Age or Digital Age), where informatics is playing a crucial role. In Information age IT- industries create a knowledge-based society which is characterized by innovations, the presence of hi-tech knowledge in every service or goods. Unique knowledge became one of the most valuable assets that can bring income and benefits and make countries, companies, universities and human beings competitive on the local and international markets. Various interdisciplinary areas are coming to the forefront and the branch of science that joins diverse areas is Informatics (biotechnologies, translational medicine, nanotechnology, etc.). These facts turn Informatics into the core discipline for studies and educational system.

It is generally accepted that ICT (Information and communications technology) has become one of the most significant and lucrative areas in modern society. ICT is an extended term for information technology (IT) which covers communications and telecommunications (telephone lines and wireless signals) and computers with necessary software, which enable users to access, store, transmit, and process information (Murray, 2011).

ICT appeared in the 70-s with the invention of a packet-switched network of computers & creation of microprocessors and began its rapid development in the 1990-s when the World Wide Web became available to mass public. However, the development and proliferation of ICT has not brought only income and advantages to the society, but negative issues as well. ICT has caused such problems as youth isolation and insularity, Internet addiction, lack of wish to work, inability to express thoughts logically, the shortage and inability of long concentrated mental activity, poor physical health of young people, etc. In other words ICT brought up the generation of mindless coach potatoes and lotus eaters. Having above mentioned qualities, the youth of today is not possible to form qualified professionals with a high level of intelligence and great creative potential, which are necessary for the knowledge-based world. But there is a simple solution to this problem. Teenagers’ obsession with computers, information

technologies and the Internet can be turned into the huge advantage that will be very beneficial for society, IT-industry and teenagers themselves in future. The solution to this problem is involvement of youth into Olympiads in Science (including Programming and Informatics). Olympiads may help to overcome problems brought about by negative influence of ICT and turn teenagers' interaction with ICT into benefits that may lead to their well-being in future.

So the main task of universities and schools is to engage as many teenagers into Olympiads in Informatics as possible, and organize the system of their further professional education in the most effective way.

### **3. The Aims of Olympiads**

The aims of school and student's Olympiads may be divided into two levels. The first level is the aims of the Ministry of Education and Science of the Russian Federation and the second level – the aims of universities.

The main objectives of Olympiads, defined by the Ministry of Education and Science are:

- To identify and develop students' creativity and interest in research activities.
- To create necessary conditions to support gifted children.
- Proliferation and popularization of scientific knowledge among young people.

The example of objectives of higher education institutions will be considered within ITMO University case. This university has a ten year experience of organizing diverse Olympiads in Science.

ITMO University identifies following fundamental aims of Olympiads. The Olympiads in exact sciences serve for identification, assessment and selection of talented and capable teenagers who are invited for further education at university. Three key components are required for knowledge society: unique hi-tech knowledge, professionals able to create this knowledge and special environment – system of education able to train them. Olympiads allow to divide the process of youth development and training into three steps: initial training, thorough professional training and improvement, which are briefly mentioned below (Pavlova and Kazin, 2016).

The first step is initial development or training. The potent tool of development at this stage is Olympiads in Informatics & Programming. Olympiads facilitate constant development, the achieving of high results and the forming of basic competences. Due to participating in Olympiads teenagers become more creative and more intelligent, they become good at STEM (science, technology, engineering and mathematics). Moreover, participation in Olympiads opens up more chances and ways in future.

The second step is intensive, profound development. Due to the first stage, universities may design and implement more thorough and advanced study programs with major in Information Technologies and as a result train best professionals in IT. Universities should turn into so-called "growth platforms". In other words, universities should create such conditions that will facilitate youth's development, formation of

high professional competences by devising and adopting best available teaching methods & technologies, attracting best teachers & researchers to educational process. “Talented people seek out opportunities to grow, and they will flock to organizations that provide ample opportunities to do so. Retention also becomes a non-issue; if people are developing more rapidly than they could anywhere else, why would they leave? If institutions are truly serious about attracting, retaining, and developing high-quality talent, they need to view themselves as growth platforms for talent where people can develop themselves faster than they could elsewhere. This, in turn, can create a self-reinforcing cycle as talent creates more opportunities for growth” (Global Human Capital Trends, 2014).

The third step implies constant development of graduates. Due to early involvement into Olympiads graduates get accustomed to improving professional competences and knowledge and maintaining qualification at high level, which is essential for life-long learning.

#### 4. Advantages and Disadvantages of Participating in Olympiads

Olympiads may have different forms: individual & command, distant & intramural, and mono- and interdisciplinary types. But all of them have a lot of advantages as they open up more opportunities to youth and contribute greatly to effective youth development.

**Admission to university without entrance exams.** Olympiads allow teenagers to enter universities without entrance examinations. The certificate (diploma) of Olympiads’ winner or awardee equals a hundred points of USE (unified state exam). Having the title of the prize-winner or awardee, teenagers have the right to pass only one exam instead of three. And exams are second to none as anxiety-makers.

**Olympiads are quality time & positive youth development.** Quality time is time which is used in the most profitable and effective way and may bring future benefits. According to Nobel Laureate Gary Becker, the amount of time spent on education in childhood is considered to be crucial contribution to child’s well-being in future (Becker, 1993). Being engaged into Olympiads, teenagers make the most of their time and invest into their future life. And self-investments are the most effective ones as they are based on motivation and lead to self-realization which is crucial for life-satisfaction.

**Olympiads impart the interest in STEM.** They involve into studying STEM. Thorough training for Olympiads may grow into vocational interests, as Olympiads encourage to keep on their studies at University. Research in these areas (STEM) is significant for any society, as knowledge-based society requires high technologies, cutting edge knowledge for sustainable economic and social growth which is considered to be the main goals of the 21 century.

**Olympiads create competitive environment.** In general, each competition (having distant form or requiring presence) is good for development, as it facilitates the shaping of competitiveness. And accumulation of talented teenagers in one place (virtual or real) enhances competitive medium. It additionally encourages and inspires youth to learn hard and achieve higher results. In other words, high concentration of talents tells positively on development.

**Olympiads raise motivation in acquiring knowledge.** Many young people have passion for programming or mathematics, and perceive them as a favourite pastime. And if you like what you are doing, you become motivated and are willing to spend a lot of time on it. As it was mentioned above, investments into yourself are the most beneficial. In general motivation is affected by: the work itself, a sense of achievement received from performing the work, recognition received for work performed; the possibility of advancement and growth; and a sense of trust and responsibility (Mallikarjuna, 2012). The fact that learners are the winners of several Olympiads proves that teenagers are very motivated (Table 1).

Despite the constant decrease of the population aged 15 to 19 (the main group involved in Olympiads) (see: Table 2), there is a rise in the number of prize-winners and winners of Olympiads, which speaks about the desire of young people to participate, win and get all the bonuses of participation.

The system of Olympiads is changing and evolving. Every year new types of Olympiads arise, e.g. Olympiads in Engineering, Olympiads in Computer or Cyber Security,

Table 1  
The structure of winners of two and more “Olympiads”, before enrolling Computer Technologies Chair of ITMO University, 2011-2016

	2011	2012	2013	2014	2015	2016
Informatics, Mathematics	21	6	16	17	19	22
Mathematics, Physics	2	2	4	6	7	7
Informatics, Physics	1	-	4	5	4	4
Informatics, Informatics	1	-	1	1	1	2
Informatics, Mathematics, Physics	1	4	5	3	5	5
Informatics, Mathematics, Mathematics	-	-	-	1	1	2
Informatics, Physics, Russian language	-	-	-	1	2	3
Overall	26	12	30	34	39	45
Informatics + other types of Olympiads	19	10	26	28	32	38

Table 2  
The dynamics of total Russian population aged 15-19 years

Indicators	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
The population aged 15–19 years, thousand	12212	11852	11244	10485	9650	8389	8237	7631	7152	6956	6829

Table 3

The results of Russian teenagers' participation in International Olympiad in Informatics

World Ranking	Gold	Silver	Bronze	Total
2	49	31	12	92

Olympiads in Nanotechnology, Robotics and others. But in each set of Olympiads' problems there are tasks covering Computer Science. The data presented in Table 1 show that the most popular Olympiads with teenagers are still Olympiads in Informatics and the data of Table 3 show that International Olympiad in Informatics (IOI) is also very popular with Russian teenagers.

Thus the data of Tables 1, 3 show that the interest in Olympiads and ambition to win are increasing. It means that youth are seeking for knowledge, self-development and intellectual work.

**Development of cognitive (mental) abilities and creative capacities.** It is generally known that progress is driven by cognition and knowledge. Cognitive abilities of the person are properties of the brain to learn and analyse the surroundings, finding ways to use the information obtained in practice. The cognitive abilities of individual are almost limitless and infinite. The Olympiads require serious and thorough preparation. To get the title of a winner one has to learn a lot in Maths and Informatics, spend a lot of time on solving problems, studying algorithms and mastering programming skills. "Informatics offers an important opportunity for developing informatics knowledge, computational thinking and problem solving skills (Kabátová *et al.*, 2016). Also Olympiads' problems usually include creative tasks (at least one). And "unlike typical problems in programming competitions, creativity tasks usually do not have an optimal solution." (Grütter *et al.*, 2016). It implies such tasks require more efforts, thinking outside the box, devising new ways. Thus, Olympiads encourage to study hard, which promotes the development of mental and creative abilities. Consequently, it helps to achieve higher results.

**Olympiads make teenagers organize time wisely.** Teenagers have many tasks at hand and often have to deal with them quickly, so they become more disciplined, learn to make the most of their time and to balance the training for Olympiads with school-related tasks and family time. Being into many activities evolves very useful qualities, such as adaptability, flexibility, mobility and so on.

**Olympiads develop important "innovative qualities" – perseverance and persistence, diligence (being hard working).** Spending a lot of time on problem solving, perseverance, hard work and persistence in achieving goals are developed. Perseverance and persistence are very important qualities for research and development, innovative society. As noted by Thomas Edison insistence and persistence are expressed in a constructive, tolerant attitude to work, when to reach the goal you have to make dozens or even hundreds of attempts and experiments. With persistence and patient approach, fail-

ures are viewed as a step that brings you closer to achieving your aims and not as another setback, which pushes to abandon the goal.

**Olympiads involve into scientific and technological sphere and create the feelings of participation in real research activities.** Olympiads' problems, as a rule, are related to real life situations. Also it is noted that "computer science is a chance to introduce engineering as a highly creative, constructive activity (Hromkovič, 2016).

Teenagers get accustomed to constant learning that turns into a favourite pastime, or hobby, and at last, into a habit, which facilitates "life-long learning".

**Selection and devotion to the craft.** Olympiads help to choose the occupation from early age. Besides, they help to acquire one of the most popular & in-demand occupation in the nearest future because of rapid development of ICT, global automation and computerization. The selection of occupation is very important as individual is bound to follow the chosen professional course for the biggest part of his or her life. When one spends on education four or six years only to find out that one does not want to pursue chosen career any more, it is not considered rational. Olympiads guide and orient oneself, help to select one's way in the wide range of occupations and trends.

To figure out if bachelor degree students are going to continue chosen career in IT area, the survey was conducted at Computer Technology Chair (Fig. 1). The study shows that most of them have the desire to continue IT-career. Moreover, the wish to work by occupation proves that: a) learners made the right career choice; b) the occupation is popular with young people; c) learners are motivated and d) learners will improve their professional competences which will result in a more highly qualified labour resource.

Preparation to Olympiads may take various forms. Teens may have classes with enthusiastic school teachers in Informatics, visit special computer clubs, take courses held by universities or just visit summer computer school. Summer computer schools are like summer camps where teenagers both have an active rest and four or six hour classes on Informatics. In camp teenagers are offered various courses with pre-defined subjects, which they select according to their interests and levels of knowledge.

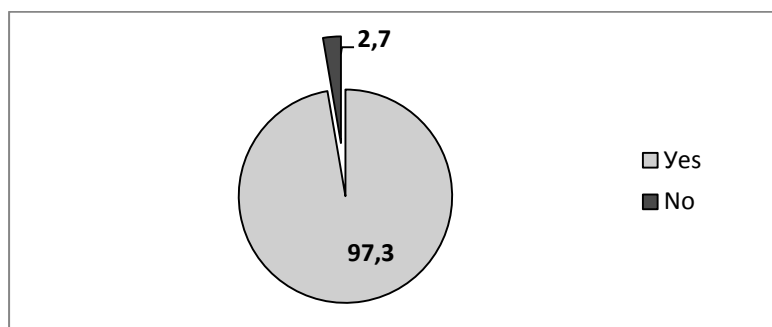


Fig. 1. The desire to continue chosen career in IT area, 2016.

Participating in Olympiads and summer computer schools allow teenagers to get acquainted with like-minded individuals, people with the common interest. Communication and companionship contribute to solving the issue of youth's isolation, stand-offishness and insularity.

Another advantage is that command Olympiads develop teamwork skills. Ability to work in a team is quite important nowadays as most research projects are carried out by big or small teams of scientists and necessary for effective interaction team members and successful project completion. Also Olympiads facilitate the development of such skills and abilities which can be useful in life. Olympiads' contests help to find solutions in short time and in the most creative way, make the most of resources available. They teach to be concentrated while solving problems, to think critically, logically & analyse problems. Participants are taught to solve tasks in intense, stressful situations and help to acquire stress resilience.

Other advantages and useful qualities, which are associated with Olympiads, are revealed in the works of an expert on Olympiads, Dagienė V. (Dagienė and Stupurienė, 2016), which confirms our conclusions about Olympiads' significance.

**Disadvantages.** Now let us consider disadvantages of youth engagement into Olympiads, if there are any. Olympiads are extra activities. "Extra" means they are not obligatory and they are supposed to be in one's spare time. The only two disadvantages that catch the eye are the problems of over-scheduling and lessening of informal socializing with peers. Over-scheduling can be bad as it may cause stresses related to work overload and less informal communication can cause poor-socialization among peers. But according to the research undertaken by the society for research in child development (Mahoney *et al.*, 2006) for the society the greater concern than over-scheduling should be the fact that many youth do not participate in any activities at all. As the well-being of youth not participating in organized activities is reliably less positive compared to youth who do participate. It means over-scheduling is better than doing nothing. And as the old adage says: "Idle hands are the devil's tools, Angels hover about the busy" (Li *et al.*, 2008). Also their research shows that youth enrolled into extra activities are able to balance their organized activities effectively with school-related tasks, family time, informal socializing with peers, and relaxing.

Thus, academics, teachers and senior university management suppose that Olympiads' fruitfulness is obvious and such competitions are well worth taking part in as they influence positively youth development and bring more benefits than harm. To find out the opinion of learners on participating in Olympiads we asked students of Computer Technology Chair to write mini essay in a free form about pros and cons of Olympiads. The results of feedback are presented in Table 4.

Judging by the table results, learners themselves identify more positive aspects in Olympiads' participation than negative ones. Thus, involvement into Olympiads affects youth in a positive way and lessens the risk of negative youth adjustment (Mahoney *et al.*, 2006).



Table 4

Pros and cons of Olympiads' movement according to the participants of the competition (data based on the research conducted among 1<sup>st</sup> and 2<sup>d</sup> year students of Computer Technology Chair, 2016)

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Pros	<ul style="list-style-type: none"> <li>• The Olympiad is a competition, and any competition creates the desire to be better and motivate you to study any subject more seriously.</li> <li>• The Olympiad is an occasion to study hard and to prepare carefully, as a result, the participants possess a deeper knowledge of the subject.</li> <li>• Olympiads open the chances to learn something more seriously, the sooner you start to participate in the Olympiads the better.</li> <li>• Olympiads are a source of new ideas, problems and solutions, thanks to them, you can think more freely and more widely, overrunning school curricula and improving their education.</li> <li>• Owing to Olympiads you can visit in a variety of interesting places and meet with peers who are addicted to the same things as you.</li> <li>• Olympiads provide an opportunity to define the aim of the future, with the occupation.</li> <li>• Olympiads develop self-discipline.</li> <li>• Olympiads allow to spend time in a useful way rather than roam the streets or hang out.</li> <li>• Excitement and responsibility during Olympiads develop patience and spirit.</li> <li>• Olympiads provide an opportunity to win a lot of prizes (including scholarships).</li> <li>• Olympiads provide admission to the University without taking into account the results of the exam (USE).</li> <li>• The trips to Olympiads help to become independent.</li> </ul>
Cons	<ul style="list-style-type: none"> <li>• Numerous trips and preparation for Olympiads take a long time as a result you have little spare time.</li> <li>• We learnt about Olympiads late, as a result we took up participating in them late.</li> </ul>

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## 5. Education Satisfaction of Those Who Were Initially Involved in Olympiads and Afterwards Acquired the Qualification in Informatics

Since 2013 Computer Technology chair has been annually carrying out a series of surveys and questionnaires for monitoring study programs in Informatics and identifying their weaknesses and strengths. The feedback from learners helps to evaluate the current situation, make some changes in the curriculum and syllabus in order to improve the quality of educational process and learning outcomes.

The results of several surveys are represented below. The one of the studies was focused on identifying the level of education satisfaction among 4-th year BA students and 2-d year MA students (Fig. 2), i.e. those students who work on their final thesis and are about to finish the cycle of studies.

The results show that most graduates are satisfied with acquired education and it means it lived up to their expectations. In particular, 94% say they are satisfied and 6% claim they are almost satisfied mentioning that they need extra knowledge in some areas (e.g., finance or biology).

Another study examines if students have a wish to continue chosen career of IT-specialist. The results show that all the graduates (100%) are going to work in IT-area,

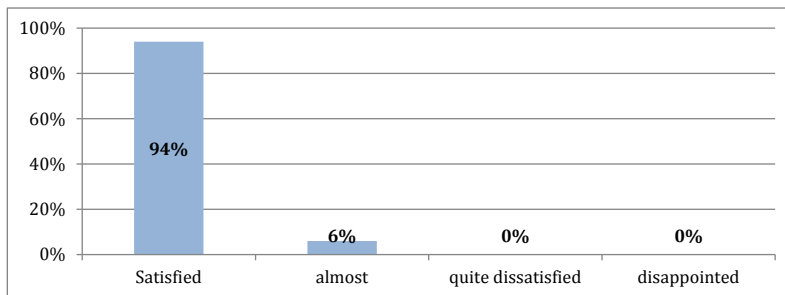


Fig. 2. The level of education satisfaction among 4<sup>th</sup> year BA students and 2<sup>nd</sup> year MA students, 2016.

which means they are satisfied with their work, will continue their development and self-improvement, they will master their competences. It implies that Olympiads contribute to the concept “Life-long learning”. The improving of abilities and skills is necessary for maintaining professional competences at a high level as IT area develops rapidly and without knowing cutting edge technologies, knowledge (qualification) may turn obsolete soon and efficiency may decrease. In its turn maintaining and perfecting professional competences will move specialists up the career ladder.

The next survey was devoted to identifying MA students’ opinion on having sufficient knowledge for work by occupation. Since the majority of MA students have permanent jobs and for most of them MA program is the continuation of the first cycle of the program, they may evaluate the sufficiency of theoretical and practical base and the level of education. The data are in Fig. 3.

The research undertaken shows that the biggest share of respondents (96%) thinks they have sufficient level of theoretical knowledge and professional competences, which is proved by their employability with leading Russian and international IT-companies (Google, Facebook, Yandex, Devexports, Mail.group, “VKO” – social network). Such success (high level of employability) is achieved not only due to internships in progressive IT-companies as a part of a curriculum. Also it happens due to substantial theoretical base acquired before and after entering the university and due to big amount of hands-on training from early age (within preparation to Olympiads). High achievements

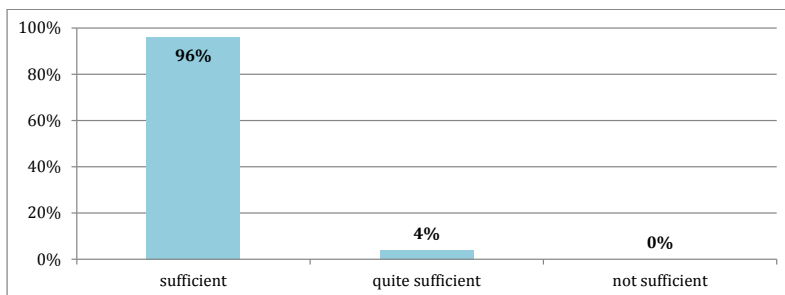


Fig. 3. Sufficiency of acquired knowledge for work by occupation, 2016.

and professional progress are only possible due to complex approach, consistent development during many years. This process starts from primary school and never finishes, that facilitates the high rate of employability.

Thus, the effectiveness of Olympiad's usage as a mechanism of training professionals in IT is noticeable and evident.

## 6. Popularization of the System of Olympiads and Its Benefits

The research proves that Olympiads are an effective mechanism of investments into youth's education and their future. It shows the interconnection between Olympiads and motivation of students in receiving the profession, proves that Olympiads contribute to the effective development of youth as an element of future intellectual and human capital and shows that Olympiads provide the opportunity to acquire a good education that will bring an interesting job, well-being and self-realization. Therefore, popularization of Olympiads and the development of Olympiads' system are important issues as Olympiads exert huge positive influence on youth development and everyone within the country benefits from the development of Olympiad's system. Country or region is provided with economic & social growth as new innovative start-ups are set up, they pay taxes, offer new services and goods and also place of employment. Companies get real IT professionals. Universities get access to best teenagers (prospective students) and become more competitive. Also university awareness arises in the minds of people. It means public learn about universities which realize competitive study programs and provide education satisfying needs of the market. And students' employability is the best advertising for universities and study programs.

So investments into children and teenagers are turned out to be justified investments as Olympiads make meaningful contributions to well-being, life satisfaction and positive outlook on life, and the list of benefits seems to be endless. What we should take into account that at present schools play the greatest role in engaging teenagers into Olympiads. The data are presented in Fig. 4.

The study shows that 66,7% respondents got to know about Olympiads from schools' staff, 16,2% – became aware of them by themselves, just surfing the Internet, 9,4% from friends, 7,7% from families.

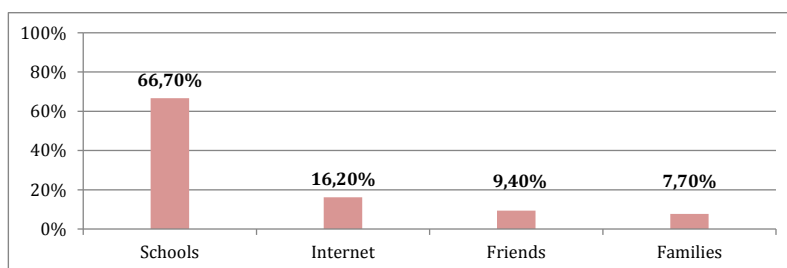


Fig. 4. How teenagers get to know about Olympiads, 2015.

– learnt from friends, 7,7% – from families. Thus, the greatest role in popularizing Olympiads belongs to school. But we cannot neglect other actors, such as universities, families and IT-companies. They have other, but also important roles. Families support teenagers, motivate them and create comfortable conditions for studying and participating. Universities take full responsibility for organizing safe and fair competitions and IT-companies maintain financially the organization of Olympiads' events and sponsor presents for participants and prize-winners, their prospective employees. The organization of Olympiads is quite a costly event, but these contests are important and the issue of raising funds emerges. Crowdfunding and endowment funds are other ways for higher education institutions to finance these events (Yanova *et al.*, 2015). It is up to universities what to choose.

Engaging teenagers into Olympiads and training them, developing and popularizing the system of Olympiads, the state and the family invest in the development of mental abilities and creative capacities of young people, i.e. they invest into future intellectual and human capital of the country. Thus, the level of Olympiads' development is the indicator to what extent the government, higher education institutions and families care about the future of their nation.

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