Japan has Joined the IPhO

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The International Physics Olympiad (IPhO) 2006 in Singapore was a momentous occasion for Japan, because it was the first time we sent high-school students to compete in IPhO and learn the international top-level high-school physics. We had spent more than five years discussing and preparing for their participation in IPhO. This article describes the path we followed to the Singapore competition, and also the great impact that the IPhO has made in Japan.

1. INTRODUCTION

Based on a long-term discussion about the possibility of Japan participating in IPhO, The Physical Society of Japan (JPS) created a small preparatory committee in 2002. Later on, The Physics Education Society of Japan and The Japan Society of Applied Physics joined the committee. The discussions continued for nearly two years, without reaching a decision about participation.

It was Korea that pushed us to make the decision about IPhO. At the annual meeting of JPS in the spring of 2004 the president of the Korean Physical Society (KPS), Professor Chung Nam Hwang, gave a plenary talk. He introduced the activities of KPS including their preparation for the IPhO 2004 being held that summer in Pohang, Korea. He appealed to the Japanese community to send some people to the IPhO. Our committee decided to send four members as observers to the IPhO 2004 in Pohang in July. The four members were deeply impressed and inspired by the huge organization of the IPhO and the high-level examinations, which triggered us to accelerate our preparation process toward participating in IPhO.

At last, these three physics societies in Japan agreed in 2004 to hold a domestic competition, "Physics Challenge", for high-school students in the summer of 2005 as one of the domestic events for the World Year of Physics. It would also serve as a preliminary screening of competitors for the IPhO 2006. We began the preparation by creating an organizing committee consisting of about twenty volunteers from universities and high schools. The committee had academic support from the three societies and financial support from the Japan Science and Technology Agency and the governor of Okayama. Thus, we were on our way to Singapore.

2. PHYSICS CHALLENGE 2005

We had about 200 applicants from high (and junior-high) schools all over Japan for the preliminary stage of our domestic competition, "Physics Challenge", in 2005 [Fig. 1]. The applicants had to submit reports on a theoretical and an experimental project they had completed. The theme of experimental project was to measure the acceleration due to gravity (g), using a home-made pendulum to test original ideas. One student tried to measure a difference of g-values between the ebb and flow of the sea. Another examined the systematic change of g-values as a function of the swing angle of pendulum. Others tried to detect a difference in g-values between ground level and the rooftop of his fifteen-floor apartment house. The committee members enjoyed

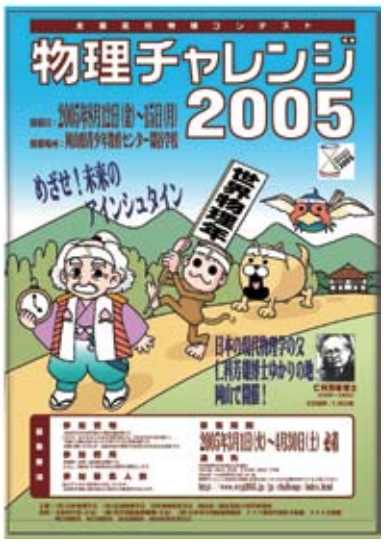

Fig. 1: Poster of "Physics Challenge 2005".

their reports very much and were already convinced of the success of the Physics Challenge at this stage.

Based on their excellent reports, we selected 100 students for the second stage of the Physics Challenge, and gathered in the city of Okayama, west of Osaka, in August 2005. The students, as well as the committee members, stayed there for four days for the competition. In the afternoon of the first day, we had an opening ceremony and welcome shows with music and dancing. We imitated the style of IPhO as much as possible. We had a five-hour theoretical competition on the second day [Fig. 2] and a five-hour experimental competition on the third day [Fig. 3]. (Unlike the IPhO, we did not need to discuss the examination problems!) After the examinations, the students enjoyed activities: making ceramic arts and visiting SPring-8, a synchrotron radiation facility, and so on. One of the important activities besides the actual competitions at the Physics Challenge was "Physics Live", in which the committee members brought their own instruments to demonstrate to the students various experiments and observations. Demonstrations included the use of magnets, a simple microscope, huge balloons, a PC, and so on. The students enjoyed the demonstrations very much and as well as discussing physics with the committee members. This was a good opportunity for the high-school students to talk to university professors.

The theoretical problems in our Physics Challenge 2005 were about relativity, diffusion, and photons, all of which were connected with Einstein. Although they were beyond the scope of high-school physics in Japan, we designed all the questions so that almost no prior knowledge about them was required (although knowledge of differential equations and integrals was assumed). This was quite different from the entrance examinations of universities in Japan. In fact, its novelty was highlighted by the surprising fact that a junior-high school student earned the top score in the theoretical examination.

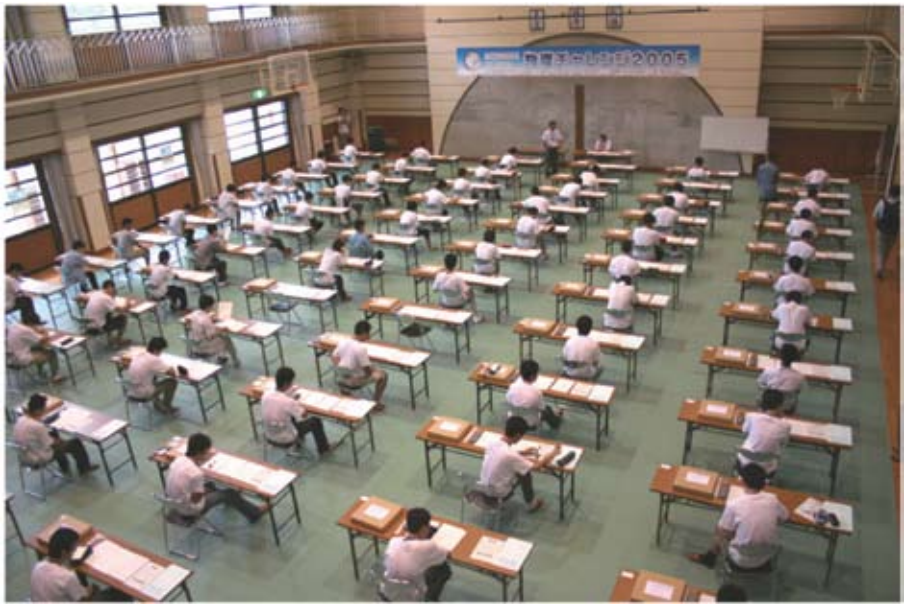

Fig. 2: Theoretical Competition at "Physics Challenge 2005".

The theme of the experimental examination was to measure Planck's constant by using the wave-particle duality of light. First, the students measured the wavelengths of light emitted from red-, green-, and blue-light-emitting diodes (LEDs) using a simple grating spectrometer. Next, they measured the threshold voltages required to light the respective LEDs, which correspond to the photon energies of the respective colors. By plotting the photon energy as a function of the inverse of the wavelength (or frequency) for each color on a graph, one can deduce the value of Planck's constant from the gradient of the fitted straight line. Although the method was different, the final goal to obtain the value of Planck's constant was unintentionally the same as that of the experimental examination at the 2005 IPhO in Salamanca, Spain held one month earlier.

The experimental competition was a novel experience not only for the students, but also for the committee members. We had never conducted an experimental competition in Japan in such a way that each student was required to do the measurements by himself/herself with individual experimental apparatus and without consulting a teacher. However, the students enjoyed it very much; nobody withdrew from the examination. Since we guessed that only a few students had experience with doing experiments in high school classes, our experimental examination was much easier than in IPhO; we did not ask for error analysis of measured data, and we described the experimental method in detail on the question sheets.

The committee members spent all night

Fig. 3: Experimental Competition at "Physics Challenge 2005".

scoring the answer sheets in time for the closing ceremony held the next morning (we did not need the moderation process, of course!). We chose 6 Gold Medalists, 12 Silver Medalists, 12 Bronze Medalists, and 20 Honorable Mentions according to the combined scores of the theoretical and experimental examinations. From the 30 medalists, we chose 12 students younger than the second year in high school as candidates of the delegate contestants in the IPhO 2006.

3. TRAINING FOR CANDIDATE STUDENTS

We started special training for the 12 candidates from September 2005. The students were asked to solve many theoretical problems and submit the answer sheets by mail every month. Students practiced experiments at their own high schools or at universities near their homes. Since this was our first experience preparing for IPhO, we did not have sufficient networks to support this training, especially for the experimental aspect. Only a few candidates went to nearby universities to meet with physics professors for training. We have learned that a country-wide network for preparing the candidates is essential. And, inversely, we believe that creating such a network increases the recognition of IPhO in the community and positively affects physics education in high schools. Actually few people in Japan knew that IPhO includes an experimental examination. The experimental competition is, we believe, one of the most important features of the IPhO and a decisive difference from the entrance examination of universities.

The final selection for the contestants for the IPhO 2006 occurred at the end of March 2006, during a four-day training camp. The 10 candidates (two had already withdrawn before the camp) studied hard and took theoretical and experimental examinations from nine o'clock in the morning until nine o'clock at night every day during the camp. In the theoretical seminars, each candidate presented his answers to theoretical problems on the black board in front of the other participants and had to answer many questions from the committee members [Fig. 4]. The committee members were surprised and impressed that most of the candidates answered the oral examinations as well as university students. Based on the combined scores of these examinations and the experimental tests, as well as the scores at Physics Challenge 2005, we selected the five best students to compete in the IPhO 2006 in Singapore.

4. THE IPhO 2006 IN SINGAPORE

At last, five Japanese high-school students were on the stage at the opening ceremony

Fig. 4: Seminar on theory at the final selection camp. Each student presented his answer on the black board, and answered oral questions from the committee members.

of the IPhO 2006 held in the auditorium at Nanyang Technological University in Singapore [Fig. 5]. That was a poignant moment for all of the leaders and observers of Japanese team, especially recalling the long path to Singapore, which turned out to be a five-year journey!

Since it was the first IPhO not only for the students, but also for our team leaders and observers, everything was new for us indeed: discussing and translating the examination problems, moderation, excursions, the mid-term and farewell parties to name a few. Japanese leaders and observers were surprised at first by the very active discussions about the examination problems just after the opening ceremony. In spite of the excellent original form of questions prepared by the Singapore committee, the questions were modified significantly as a result of the discussion by the leaders from all participating countries. We knew that the IPhO was run democratically, but as a result, the discussions took a very long time. It took more than 10 hours to discuss and correct the theoretical problems, from one o'clock in the afternoon to almost midnight. Therefore, after the final version of the problems was approved, we had to work all night to translate the problems from English into Japanese. The Japan team finished the translation at six o'clock the next morning, just two hours before the start of examination! The Japan team had five observers to assist the two leaders. All of them worked really hard all night without a break, but it took six hours. This was because we chose words very carefully in the translation to avoid any possible misunderstanding by the students during the examination.

Another feature that was quite new for us was that the theoretical examination did not include classical mechanics. The problems were about a neutron interferometer, special relativity, optics, thermodynamics, and electromagnetism. This was shocking to us because in Japan we believe that classical mechanics is the most important topic in high school physics. We felt that this composition of the theoretical questions conveyed a message about the policy of physics education in Singapore.

The experimental examination was also very interesting. The theme was to measure interference and diffraction of microwaves. Typically, our high-school text books present this theme as a 'Gedanken experiment', but we seldom perform an actual experiment in high school classes. The unique feature of the examination was the format of the question. The instructions for the experiment did not tell the contestants how to set up the experimental apparatus; the contestants had to determine the proper arrangement of the apparatus by themselves. The Japanese students were at a loss and wasted much time taking unproductive measurements. The typical physics experiments in Japanese high schools and even in undergraduate schools of universities require that the students have only to assemble the experimental tools and do the measurements according to the given directions; they do not need to design the experiment. The experience at this IPhO may be a good trigger to reconsider the style of education in Japan.

The leaders and observers of our team slept well in the hotel during the competitions while the students struggled with the problems, because we had worked all night on the translations. No one had the energy to participate in the excursions for leaders and observers. Surprisingly, we received our students' answer sheets at midnight on the competition days. We began to score them immediately since the leaders and observers had already reversed day and night to work on the translations.

Fig. 5: The contestants of the Japan team at the opening ceremony of the IPhO 2006 in Singapore.

The Japan team (as well as other Asian participants) was excited to meet Professor Masatoshi Koshiba, Nobel laureate of Physics in 2002, as a special guest at the mid-term party held in the evening after the experimental competition. That was a quite big party with all the participants gathering to cerebrate the successful competitions. The students looked very relieved since they had finished all the exams. Since our leaders and observers drank a lot of wine there, we didn't start to score the answer sheets of the experimental examination until after two o'clock at that night.

Moderation was also a new experience for us. The final score of each contestant was determined by a discussion between

the leaders of each country and members of the Singapore scoring committee. Since the leaders and the committee members scored the answer sheets independently, naturally enough there were some differences in the scores. We discussed the differences and adjusted the score of each student with (or without) mutual agreement (the Singapore committee had the final say). We prepared for the moderation all the night before and developed some strategies to get the highest scores. The results of the moderation were, however, quite reasonable; we recognized that the scoring committee was quite fair and very careful about the detailed scoring scheme, even though they did not understand the Japanese written on the answer sheets. We imagined how tough it is to score fairly answer sheets written in foreign languages.

At the closing ceremony, the students were seated in the auditorium in the order of their scores, so they already guessed the color of their medals before the ceremony. However, we were deeply moved watching our students receive their awards on the stage. Although no Japanese student earned a Gold medal, all the students received Silver/Bronze medals or Honorable Mention [Fig. 6]. We believe that this was a really successful result for our first IPhO. We really applauded our five students.

5. CONCLUDING REMARKS – THE IMPACT OF THE IPhO

The results of International Science Olympiads, not only the IPhO but also the Math, Biology, Chemistry, and Information Olympiads held in the summer of 2006, were covered widely by newspapers and magazines in Japan. The reports were exceptionally prominent in 2006, because, we believe, Japan sent a Physics team for the first time. The Ministry of Education, Science and Culture decided to support systematically the activity for the International Science Olympiads, and began to discuss how to attract more high-school students to the preliminary screening. They set several thousand as a target number of applicants for future Physics Challenges, which was one order of magnitude larger than that in 2005!

At the end of August 2006 our Prime Minister, Mr. Jun-ichiro Koizumi, invited all the medalists from the International Science Olympiads to his official residence. At the meeting with the Prime Minister, one of our contestants in the IPhO showed the Prime Minister one of the experimental tools and explained the competition. Our Prime Minister replied, "I do not understand physics at all! But it was quite good to hear that all of you had valuable experiences in an international environment. I expect you to make use of such experiences in your daily studies and in finding your way in the future."

Under the support of Ministry of Education, Science and Culture, the Japan Committee of Science Olympiads (JCSO) was created in the beginning of 2007, chaired by Professor Leo Esaki, Nobel laureate of Physics in 1973. The Japan Committee of the Physics Olympiad is now a sub-committee under JCSO. We believe these big changes occurred in 2006-2007 due to our participation in the IPhO 2006. The positive effect, however, has not yet reached each high school and each student sufficiently; actually, the number of applicants for the Physics Challenge in 2006 and 2007 remained as few as 300-400, far below the target number set by the Ministry. But we are realizing that more people are interested in and understand the importance of IPhO. This is partly because of a recent tendency in Japan that fewer high-school students are interested in science. Many teachers and professors, as well as the government, worry seriously about this situation. The International Science Olympiads, including IPhO, should help change this trend. To alleviate this problem, we have to go abroad and learn the global standard of physics education. The IPhO provides us a great opportunity to do that. It can encourage us to reconsider and restructure the physics education system in Japan. The IPhO not only encourages the elite students, but, more importantly, expands the horizons of everyone interested in science.

Fig. 6: The Japan team after the closing ceremony of the IPhO 2006 in Singapore. One Silver Medal, three Bronze Medals, and one Honorable Mention.