Assen Kyuldjiev

Institute of Nuclear Research and Nuclear Energy,
Tzarigradsko chaussee 72, Sofia 1784, Bulgaria

Email: a.kyuldjiev@gmail.com

PISA 2015 assessment, IYPT and education

ABSTRACT

The recent PISA 2015 assessment provided a good reason for educators and the general public alike to ponder on the competences needed in the modern world. It also provides an opportunity for the IYPT community to stress that in the past 30 years the Tournament has been an embodiment of the values which are exalted nowadays by the avant-garde trends of science education.

Still, IYPT does not fully enjoy the visibility and popularity it deserves and our community could probably do more to make it more apprehensible. Some ideas in this respect are proposed for discussion.

Keywords

PISA 2015.

PISA & IYPT

PISA seems to be the most prestigious and talked about large-scale international students' assessment. It takes place every three years and evaluates the competencies of 15-years old students in *science, reading and mathematics.* A few months ago the first results of PISA 2015 assessment were made public and now a lot of educators worldwide are examining them and try to identify directions for improvement of their educational systems.

The focus of the latest assessment was on science and that's why it was designed to provide additional insight on the different aspects of the science literacy. First and foremost, the definition of *scientific competencies* as used in PISA 2006 have been reconsidered and redefined.

According to PISA 2015 definition, a science-literate person is able and willing to engage in reasoned discourse about science and technology. This requires the competencies to [1]:

- *Explain phenomena scientifically* – recognise, offer and evaluate explanations for a range of natural and technological phenomena;
- *Evaluate and design scientific enquiry* – describe and appraise scientific investigations and propose ways of addressing questions scientifically;
- *Interpret data and evidence scientifically* – analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions.

Consequently, the test problems used in the assessment have been reconsidered and formulated accordingly. This change is telling as it reflects the recent trend for a greater emphasis on introducing elements of scientific enquiry in the schools [1]:

> When students seek knowledge and understanding, adopt a questioning approach to all statements, search for data and their meaning, demand verification, respect logic and pay attention to premises, they can be said to have a "scientific attitude" and to support scientific approaches to enquiry. Indeed, these are the features that characterize scientific thinking. Such beliefs and dispositions have been shown to be directly related both to students' ability to acquire new knowledge in science and to their grades in school science. [2]

Of course, similar goals are present in the standards' documents for science education in many countries. Still a good part of science teaching is quite ignorant of these goals, the implementation of corresponding teaching concepts is poor and there is a lot more work to be done.

There is also another telling development since PISA 2012. To further attune it to the modern needs, the standard assessment of reading, math and science has been supplemented by an optional evaluation of *problem solving skills.* (Problem solving competency was defined as the capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious.) In PISA 2012 the evaluation was focused on *Creative* Problem Solving and in PISA 2015 the focus was on *Collaborative Problem Solving* – activities which are quite familiar to the IYPT community. Looking at the number of recent PISA refinements running parallel to the 30-years long IYPT practice, one may be left with the feeling that there are a lot of IYPT admirers in the PISA offices.

I am not aware of any other international secondary school students' competition which epitomizes to such extent the spirit of the scientific research as IYPT. (Of course, the same is also true for the tournaments which are closely modeled upon it like the Junior Young Physicists' Tournament and the International Young Naturalists' Tournament which are for the age group of 12-16 years.)

Yet, among the other international competitions, IYPT is seen as a boutique tournament which

has never been able to gather more than 30 teams. It is still a matter of passion for a not so big bunch of enthusiasts who often take its virtues as self-evident. Yes, our Tournament is unique but our community could probably do more to make it more visible and popular, could try more arguments in its favour and also provide better support for the newcomers and those who consider participating in IYPT.

Regarding the interaction with the educators, PISA has provided us with ample supply of arguments about the value of any activities mirroring the "real-world" scientific research in the classrooms and school laboratories. Of course, PISA could not explicitly mention IYPT as exemplary competition in its publications – it's our task to do so and make the best use of the ammunitions provided.

Except for the methodology arguments, at least two more things come to mind in order to facilitate the popularization of IYPT.

IYPT problems in schools. There is an enormous wealth of problems and solutions in the Tournament's archives. The access is open and free but nevertheless, this treasure house is rarely tapped by the educators. I dare say that there is a need to supplement it by a depository for IYPT problems which have been *adapted for use in schools*, together with guidelines how to approach them.

One may also dream about a sort of national/regional **Young Physicist's FEST** with attractive presentations and live experiments in a relaxed and festive atmosphere. This would be a place where teammates could show solutions which they have not been able to present at the IYPT, together with students which have not participated in the Tournament but have worked on IYPT- or IYNT-type of problems in their school labs.

Help with the entry barrier

It is not easy for newcomer teams to comprehend all aspects of the Tournament even when they have a leader who has been a visitor at IYPT. The problems they have to tackle are not the typical ones they have faced till then and they may wonder just how to approach them. Quite often such teams are genuinely not able to understand why they have got low grades. We could possibly present a more detailed explanation of what teammates are supposed to do, what is the rationale behind it and to give them some idea about the spectrum of approaches to the problems of the past Tournaments.

Conceptual framework. I have the feeling that despite the explanations found in the IYPT site, *Regulations and the Reference Kit,* there is still some space for further elaborations on the conceptual framework of IYPT from different viewpoints.

To give my two cents worth I tried to summarize the tasks for the Reporter, Opponent and Reviewer. I'd like to add few words to explain some of the notions used.

The tasks for the Reporter, Opponent and Reviewer

Depending on the specifics of the problems, some of the items listed below may not be applicable/ appropriate.

MetaTasks for the Reporter:

- Explanation, Investigation and/or Empirical study of a phenomenon
  - · achieving theoretical understanding of the phenomenon
  - · design of experiments, obtaining experimental data and comparison with the theoretical propositions
- Fulfillment of the problem-specific tasks (when there are such)
- Drawing conclusions
- Communication and defending of the investigation done

With emphasis on:

- Novelty and originality of the investigation

Achieved by:

• a presentation of the appropriate concepts, theories and principles of the problem • providing a qualitative explanation of the phenomena observed • reasonable experimental techniques to gather and process data for a quantitative analysis (or demonstration of the phenomena, if appropriate) • proposing of appropriate mathematical model and making predictions • linking of theoretical and experimental findings • refinements of the theory and modification of the experiments (whenever appropriate)

What's also expected: • logical structure of the report • errors estimation • discussion and testing of alternative hypotheses • references, proper citations of ideas and input of others, clear indication what the Reporter's own contributions are • accurate answers • constructive contribution to the discussion • communication of difficult or complex ideas in an effective and understandable manner • varied parameters/materials • appropriate manners

Extras: use of dimensionless parameters, 'phase diagrams' of different regimes, etc.

MetaTasks for the Opponent [*CRITICAL* evaluation of Reporter's MetaTasks fulfillment with focus on *PHYSICS*]:

- Questions the Explanation and understanding and/or the methodology of the

Empirical study of the phenomenon

- Critically evaluates the fulfillment of the problem-specific tasks (when there are such)
- Challenges the validity of the conclusions drawn or the reasoning behind them
- Critically evaluates the Communication of the investigation

With emphasis on:

- Finding and prioritizing errors and shortcomings in the report
- Leading a thoughtful DISCUSSION, expressing own opinions and adequately summarizing the outcome of the discussion

Achieved by:

• challenging the Reporter's understanding of the presented concepts, theories and principles • critiquing the experimental techniques used and questioning the validity of the experimental data • discussing the appropriateness of the mathematical model and its limitations • making good use of the allocated time to appreciate the strengths and to highlight the shortcomings and errors in the Reporter's actual solution and to prioritize them • appropriate manners

With the ultimate aim to find and expose some grave misconception or flaw in understanding of the phenomenon (if any).

What's also expected: • response to the Reporter's actual solution • asking relevant questions • accurate answers

MetaTasks for the Reviewer [***OBJECTIVE*** evaluation of Reporter's and Opponent's MetaTasks fulfillment with focus on *PHYSICS*]:

- Evaluates the explanation/understanding/methodology of the Reporter, and Opponent's criticism
- Critically evaluates the fulfillment of the problem-specific tasks and Opponent's judgment of them (when there are such)
- Evaluates the validity of the conclusions drawn and Opponent's assessment of them
- Evaluates the Communication of the investigation, the way Opponent was leading the discussion and the discussion itself

With emphasis on:

- Expressing own opinions on the topics discussed
- Drawing attention to the essential points missed by the Reporter and/or Opponent (if any)

Achieved by:

• giving an objective review of the performances the Reporter and Opponent (but not a recollection of the previous 30 minutes) • highlighting the important aspects (especially the controversial ones) • clearly stating Reviewer's personal opinion • prioritizing of the critical comments about the Reporter and Opponent

With the ultimate aim to find and expose some grave misconception or flaw in understanding of the phenomenon (if any).

What's also expected: • response to the Reporter's actual solution and to the Opponent's actual assessments • response to the actual discussion • asking relevant questions • accurate answers • reacts to overdone praises or unjustified criticism of the Opponent • appropriate manners

In most cases, the definition of problems requires reproducing and *explaining* of some phenomenon and its *investigation* at a deeper level. Sometimes it is possible to find a theoretical model of the phenomenon to guide the investigation but in other cases, an *empirical study* seems more reasonable. For a small number of problems only, teammates are expected to optimize certain characteristics of devices which they had designed and constructed.

The structural tasks which are typical for most of the IYPT problems are called here *MetaTasks* in order to distinguish them from the assignments of the concrete problem. I see no need for any explanations about the first MetaTask, as it concentrates anyway most of the attention during the fights. The rest of the MetaTasks seems overlooked and it's my deep conviction that they also *do require evaluation*, even if, in one sentence only.

For less than half of the problems, there are also specific tasks which specify what should be done beyond the standard "Investigate the phenomenon and how it depends on the relevant parameters", such as "…investigate how well it can resolve density differences", "…maximise muzzle velocity", "…optimize [the parameters] to get the maximum height [of the fountain]" etc. These are called here *problem-specific tasks*.

Post-Tournament assessment of the problems. We already have a good archive of solutions plus peer reviewed articles in *IYPT Magazine* but as they do not always present all facets of the subject, some comments on the possible approaches might be helpful. Such annotations could provide information about how different teams have tackled the problems, what were the jurors' expectations and what have been lacking. It would be nice if teams get some feeling about the spectrum of approaches to the problems, what was expected by an entry-level team and what by a team with ambitions for high-quality medals.

Anyway, teams need to be assured that any sensible use of *quantitative analysis* and *common sense* shall be welcomed and whatever combination of meaningful directions they choose to pursuit,

the jurors shall appreciate their efforts.

Discussion

The author would be happy if this article provokes a discussion on the topics mentioned. All members of the IYPT community are welcome to object, reject, correct, append, comment, etc.

References

[1] OECD (2016), PISA *2015 Results (Volume I): Excellence and Equity in Education,* PISA, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264266490-en

[2] Mason, L. et al. (2012). Besides knowledge: A cross-sectional study on the relations between epistemic beliefs, achievement goals, self-beliefs, and achievement in science. Instructional Science, 41(1), 49–79. http://dx.doi.org/10.1007/s11251-012-9210-0

SOLUTIONS TO IYPT PROBLEMS

Articles recording details of experiments, and solutions to IYPT problems are collected from talents worldwide.