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Inquiry-based science education and the International Young Physicists' Tournament

Abstract

The International Young Physicists' Tournament (IYPT) Association is committed to providing physics competitions for upper secondary students that stimulate their active learning, compel them to perform stringent experimental work, develops their team-work skills and raises their interest for physics and related disciplines. The unique nature of the tournament provides an ideal method of integrating successful inquiry-based learning into secondary schools and inspires a greater interest in, and understanding of, the nature of science. Since there is a global decline in the interest in science, and physics in particular, IYPT has a very important role of stimulating the curiosity of students through observing natural phenomena, motivating them to 'search for understanding' using the scientific method, and strive for excellence through friendly competition. This article is written from the perspective of a classroom teacher with the intent of providing an introduction to the educational theory supporting the benefits of inquiry-based learning and open-ended experimental investigation. It outlines the concept of the tournament itself and justifies that IYPT is an exemplary model for all classrooms to use as the foundation of their learning.

The International Young Physicists' Tournament, (IYPT) is a competition based on a student's own theoretical and experimental research. The research is then presented and defended in the "physics fights" that form the structure of the tournament. This makes it a very different experience for a student than the more usual examination based events.

IYPT is also an educational philosophy. Educational theory points toward the introduction of a constructivist learning environment into our classrooms if students are to be successful. Many papers have been written over the years promoting problem-based learning (PBL), inquiry-based learning (IBL), or inquiry-based science education (IBSE).

"Inquiry-based learning is gaining increasing support in science education, with a growing number of educators becoming interested in teaching which involves projects or inquiry. It is an approach which engages students in activities which mirror methods of scientific investigation, with content interwoven with or addressed in the context of inquiry." (Kubicek, 2005)

Studies have also shown that attempts to introduce IBL into classrooms have not always been very effective. Having the conviction to introduce inquiry learning into a curriculum dominated by a knowledge-based syllabus is fraught with difficulty and it is not always easy to convert this conviction into a workable curriculum.

It is important that students be given opportunities to practise science as professionals do. Only then will they appreciate the process of science. "To be effective, inquiry learning should include the basic abilities of conducting a scientific investigation as well as an understanding of how scientists do their work" (Kubicek, 2005).

The culture of science education is, at best, only an approximation of expert practice for a scientist, with the very nature of schooling causing a distortion in the cultural transmission from professional to school practice. Real research rarely fits into a predetermined period of time and tasks designed for use within the classroom have often been limited artificially. Without considerable planning, teachers can transform the complex, socially embedded processes of scientific sense-making into traditional, easily-managed, teacher-centred school tasks. The problem with much inquiry-based learning is the inappropriate nature of the tasks set in order to make them 'classroom friendly'. In doing so, students lose ownership of the inquiry often resulting in a superficial understanding as they did not have the opportunity to construct their own knowledge. As Savery & Duffy state "if the students are to engage in authentic problem solving, then they must own the problem".

An authentic research task is one in which (a) new knowledge is constructed, (b) disciplined inquiry is used to construct knowledge, and (c) the task outcome has personal, aesthetic or utilitarian value. The search to find authentic tasks or problem-solving activities that could fit into a curriculum is complicated. Students need to be exposed, not only to the physical experiences that define the culture, but also to the concepts and models of conventional science alongside the nature and status of scientific knowledge. They also need to be able to make, support and rebut a case, collect empirical data to be used as evidence, and use explanatory models as a theoretical means for accounting for what has been observed. Only then will students truly have ownership of the inquiry.

IYPT was created in the USSR to foster scientific research and improved international communication in Physics. The competition promotes real research into authentic problems. The research carried out is open-ended and simple solutions are not available. The students "do science"

rather than traditional school laboratory activities and have to utilise higher order thinking skills to make progress.

IYPT provides a physics teacher with the perfect vehicle to introduce more inquiry-based learning into the classroom. The seventeen problems that form the basis of each tournament have been carefully selected to provide open-ended tasks. A competition where a student needs to present research and defend their findings against the opposition of their peers cannot have simple defined answers or discussion becomes meaningless. The tasks encourage the students to interpret the problem and investigate the elements they consider important. The student takes ownership of the task and will spend many weeks or months trying to produce a solution. With no pre-expected answer, the student researches to find new knowledge. Knowing they will need to discuss their findings in competition means they must work in a disciplined way. To be involved in an international competition provides a clear personal motivation.

Inquiry-based learning has been summarized as having 6 stages: initiation, selection, exploration, formulation, collection, presentation and assessment. (Kuhlthau, 2007). Reflection and self-assessment is also vital throughout the process. This seems to be a description of IYPT.

The use of open-ended tasks also creates a different dynamic between the teacher and student. The concept that the teacher knows the answer has to disappear since the work the student conducts generates new knowledge. The student's ownership of the problem means the teacher is a guide, a facilitor, a research assistant and collaborator. The teacher is someone with whom to discuss ideas and probe the student's own understanding. They are a vital role in the student's journey as they model the behaviours of a scientist and are an expert in the scientific method. As a teacher this can be a very rewarding approach to physics, liberating them from having to be the traditional 'fount of knowledge' and becoming a partner in the pursuit of understanding our complex world.

Performing IYPT tasks helps students understand that the scientific community has ways of dealing with less than rigorous strategies and improved rigour during scientific investigations becomes a characteristic of an IYPT student. Students are required to reflect on the selection, utilisation and outcomes of their strategies and to continue adapting these until they achieve some sort of confidence in their results. Past practices rarely set aside time for this to happen. Nonetheless, it seems that the shift in science schooling from a culture of certainty to one of uncertainty improves the rigour of any school-based inquiry. Consequently, one of the most remarkable changes that results from a student's involvement with IYPT is the repression of the "illusion of certainty" during laboratory investigations and the acceptance of scepticism and uncertainty as being right and healthy. Uncertainty is the beginning of learning. (Kuhlthau, 2007)

Students know that the scientific process has not ended with the competition. The students still want to talk "their physics" long after the last scores are given. In 2007 Kathryn Zealand from Australia had presented her solution to the problem "water jets" in the Final and helped her team to victory. That evening, a group of students from the Ukraine showed her a video of their findings from a completely different interpretation of the task. Both parties enjoyed the continued discussion of physics and had a genuine interest in what others had done – the students were demonstrating they were becoming informed and critical scientific citizens. So even though Kathryn was confident earlier that day her findings were 'correct', she came away amazed that she had missed a whole different phenomenon based on the same task statement. The introduction of the IYPT Magazine is to provide another opportunity for students to present their findings and continue their involvement in the process of science beyond IYPT.

Much has been written about the global decline of interest in physics education, its causes and its implications. Educational institutions all over the world are unable to provide a quality physics programme for its students because of a lack of expertise among the teaching staff and the paucity of suitably-qualified applicants. Many universities have closed the research portions of their physics departments or closed the departments altogether. Studies have also shown this is a problem at both secondary and tertiary levels. In 1997/8 the European Physics Education Network (EUPEN) compared undergraduate physics across over thirty European countries. In 2000/1 the Institute of Physics (IOP) in the United Kingdom conducted a similar inquiry into undergraduate physics, in 2001/2 the American Association of Physics Teachers (AAPT) created the National Task Force on Undergraduate Physics to study the situation in the United States of America and in 2004/5 The Australian Universities Teaching Commission (AUTC) established a similar project in Australia.

Even in the emerging superpower of India studies made both at secondary and tertiary levels highlight a shift away from science with less than 3% of school children interested in science careers (Varghese, 2005). Indeed most students found science boring and, consequently, did not engage with their lessons.

Students conducting research into IYPT problems do engage. In the Australian State of Queensland it is mandatory that all high school students studying physics conduct an extended experimental investigation for assessment. Several schools have selected the problems of IYPT to be the source of these tasks and the very best can compete to be selected in the Australian Team. These schools include those that are not academically selective and are for girls only, boys only and co-educational. The problems of IYPT prove to be a very effective tool for IBSE.

In 2010 an adapted version of the competition was also created to provide the possibility of

bringing the IYPT approach to younger students. The Junior Young Physicists' Tournament (JYPT) is aimed at schools rather than national teams and for students under the age of sixteen. It has now been held twice and schools from four countries have competed. These young students that have competed come back to school with an increased confidence in themselves, a stronger passion for learning physics and engage in scientific discussions more readily with their peers,

In 2007 The European Commission produced a report entitled "Science Education Now: A Renewed Pedagogy for the Future of Europe". The report restated concern over the decline in young people's interest for key science studies and mathematics. In summary it recommended:

"A reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods provides the means to increase interest in science. Inquiry-based science education (IBSE) has proved its efficacy at both primary and secondary levels in increasing children's and students' interest and attainments levels while at the same time stimulating teacher motivation. IBSE is effective with all kinds of students from the weakest to the most able and is fully compatible with the ambition of excellence. "

The IYPT approach provides inquiry-based science education that can be used with students of all abilities and provide an avenue for the most able to excel.

The introduction of the IYPT Magazine gives teachers and students a valuable resource to aid them with IYPT inquiry-based science education to the benefit of us all.

IYPT is also a lot of fun!

Thank Catherine Clémot for her assistance with this article.

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