RESOLUTION on the Importance of Active Learning and Hands-on Physics Education

(Draft)

IUPAP urges that National Governments, Physical Societies, Funding Agencies, Physicists, and Physics Educators in all countries

- support best practice of physics education and physics education research at all levels by encouraging teaching methods, including laboratory work, that actively engage the hands and minds of learners.
- make available funds for establishment of well equipped laboratories and designing appropriate curricula that lay particular emphasis on teaching the skills of the experimenter.
- support indigenous development of low-cost instruments, physics apparatus and equipment, and — when finances allow it — computer-based data-acquisition systems for real-time measurements at the appropriate level of sophistication for a variety of uses in teaching of physics in the classroom and the laboratory.
- support curricula that teach physics with an appropriate diversity of methods, including hands-on approaches, that encourage critical thinking and help students understand how physics is relevant to their local cultures and to a sustainable future for humankind.

Background to the Resolution on the Importance of Active Learning and Hands-on Physics Education

Physics is an experimental science whose aim is the observation, description, modeling and understanding of the natural world in which we live. The process of reproducing phenomena in the laboratory enables scientists to study, in quantitative detail, aspects of specific phenomena, and to understand specific concepts. Modern methods of measurement and techniques of instrumentation contribute to the advancement of science and to its applications. It is thus natural to include work in a well equipped laboratory in the teaching of physics.

Moreover, contemporary research in the teaching and learning of physics indicates that hands-on activities and other interactive approaches, when integrated in teaching, lead to an increase in student understanding of the subject.

We are thus gravely concerned that, across the world, the predominant mode of teaching continues to be textbook based lectures. Laboratories are underused, or not used appropriately, as a part of the learning process in both developed and developing countries. Very few institutions, including those in developed countries, provide active learning techniques which are integrated throughout the students' learning of physics and which can help students visualize the physics they are learning and enhance their qualitative and quantitative understanding. Even where laboratory work and/or hands-on activities are an integral part of the curriculum, they often follow a cookbook approach that fails to impart procedural and conceptual knowledge about the activity, which then becomes hands-on without engaging the students minds.

Such an algorithmic approach imparts neither the craft of the experimenter nor an understanding of the physical world. Students fail to grasp concepts of reliability and validity of data; the significance of errors of measurement and measurement uncertainty; and the notion of refining the process of measurement to obtain the desired accuracy. Nor do they appreciate the inherent

interplay of theory and experiment in the progress of science. All of these should be outcomes of effective education in physics.

Systematic research on students' conceptions of physics has shown that students bring to the classroom their own thoughts and views about the world. For teaching to be effective, the student must be made an active participant, rather than a passive recipient, in the reconstruction of his or her own knowledge. Effective teaching-learning environments, whatever be the relative emphasis on textbook-based lectures, problem-solving or inquiry-based learning, recognize the importance of hands-on activities, laboratory and project work.

In some countries hands-on activities are being integrated effectively into teaching of science in the early years of school, and, where available, provide an important base for active learning of physics in later school years and in universities. These successful strategies need wider adoption and dissemination at all levels.

To help give effect to the resolution, we suggest that

- special sessions be organized on educational aspects of hands-on learning, experimentation, and appropriate assessment, in discipline specific conferences of the IUPAP commissions.
- multinational collaborations and workshops be organized for design and development of resource material for active learning and laboratory work; and further, dissemination through professional training of physics educators.
- electronic resource centers be established for exchange of ideas about local initiatives, teaching materials, prototypes of "hands-on" equipment, in particular those that can be locally adapted for construction by the teachers and their students, to serve a variety of educational needs in diverse cultural contexts.