IUPAP INTERNATIONAL UNION OF PURE AND APPLIED PHYSICS

International Newsletter on Physics Education

ICPE

International Commission on Physics Education • International Union of Pure and Applied Physics

Number 48 October 2004

WORLD CONFERENCE ON PHYSICS AND SUSTAINABLE DEVELOPMENT

World Conference on Physics and Sustainable Development will be held on 31 October to 2 November 2004 in Durban, South Africa. The primary sponsors of this event are: UNESCO, Abdus Salam International Center for Theoretical Physics, Trieste (ICTP), International Union of Pure and Applied Physics (IUPAP) and South African Institute of Physics (SAIP).

The conference will review the contributions that physics has made to society in the past and formulate a plan for the contributions that it can and should make in the future.

In part, it will be a follow-up to the UNESCO-ICSU World Conference on Science which was held in June 1999 and sought to strengthen the ties between science and society, as well as to the broader United Nations World Summit on Sustainable Development that was held in Johannesburg in the summer of 2002 and to the ten reports that ICSU developed in preparation for the Summit.

It is the intent of the conference organizers to place particular emphasis on how physics can do more to help progress in the developing world. This conference is expected to lead to important action items for which organizations of physicists, including national physical societies, will join hands to implement them collectively.

Approximately 500 people, physicists and policy-makers alike, from all parts of the world; strong emphasis will be placed on participation from developing countries.

The conference will have the following themes:

- Physics and Economic Development
- Physics and Health
- Energy and the Environment
- Physics Education

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ICPE Sponsors International Physics Education Conference 2005 in India

In celebration of the World Year of Physics 2005, the International Commission on Physics Education (ICPE) will sponsor an international conference entitled, "World View of Physics Education in 2005: Focusing on Change" to be held on August 21-26, 2005 in New Delhi, India. The convener for conference is Dr. Pratibha Jolly of University of Delhi which is also the host institution. (*Details may also be viewed at http://education.vsnl.com/pjolly*).

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In this issue

THE GLITTER PATH: AN EVERYDAY LIFE PHENOMENON RELATING PHYSICS TO OTHER DISCIPLINES

H. Joachim Schlichting
Department of physics, University of Muenster
PO 48149 Muenster, Germany,
schlichting@uni-muenster.de

The sun's reflection becomes a shining sword on the water stretching from shore to him.
Italo Calvino

The many faces of the so called glitter path are presented to draw attention to an optical phenomenon which is not only interesting from a physical point of view but is also important in other contexts. It is shown as well, that this phenomenon may occur in many situations totally different from the original wet ambiance.

Introduction

The phenomenon of the setting sun's reflections painting an elongated shiny path of light on the surface of wavy water is well known. Although physicists will regard it without hesitation as a physical phenomenon, non physicists including our students who experience this glitter path will be more affected by its non physical aspects. Like other natural or everyday life phenomena the glitter path may be regarded from different perspectives.

Fig. 1: Glitter path at the setting sun

First of all it is a popular motif of postcards, where it may be found not only associated with the setting sun but also as light streaks on rivers, channels and wet streets reflecting street lighting and other light sources.

Moreover, the light path is a favoured motif in art throughout the centuries. Some painters as e.g. William Turner and Edward Munch spent much time on it exploiting its imagery and its esthetical and affective dimensions.

In literature the glitter path has been described for many times. Like the painters the poets were not only interested in the natural phenomenon itself but tried to express or intensify emotions and esthetical sensations, or used it as a metaphor to illustrate their philosophical reasoning.

The light path is considered as an example of an everyday life phenomenon qualified to refer to important aspects of learning physics within a non-physical context. We expect that we may take advantage of the motivation originating from the non physical aspects of the phenomenon to get the students interested in the physics behind it. Furthermore, the students should learn that the physical aspect of everyday life matters is just one aspect among others.

We first give a description of the physical background of the phenomenon and then sketch how the various forms occurring in differ-ent situations may be modelled mathematically and reproduced by a simple computer simulation.

Fig. 2: The typical shape of a glitter path when the sun in not to low.

It can be expected that the physical understanding may help the students to detect glitter paths in totally different situations: Light beads on tiled floors, on smooth metal surfaces, on CDs. They all have wavy surfaces in form of ripples and scratches, and their behaviour may be found and be recognised as being based upon the same physical principles.

Finally, it is shown that by looking through transparent plates similar light patterns can be detected, which are no longer due to reflection but to refraction at ripples and scratches.

The glitter path in non-physical contexts

Light paths and light bands can be found in many paintings. First of all they are powerful manifestations of light sources like the sun or street lamps in the surroundings, in that they multiply and modify the light impression by interacting with non luminous objects. Regarding the painting it becomes obvious that the painters often needed more paint for the light path than for the light source from which it originates. Conversely, the reflections are an important means to show the detailed structure of the water surface, which - due to the

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The 2005 conference will be the first time that the international physics community focuses its attention collectively on these themes and the interplay between them. There will be a Programme Committee for each topic that will outline the problems, write white papers proposing contributions that physics can make, and propose follow up actions.

UNESCO, ICTP, IUPAP and SAIP have all pledged their financial support, but additional major funding will be needed to make the conference a success. Because the organizers want to have many participants from developing countries, it will be important to fund their travel expenses.

Minella Alarcon
UNESCO Paris

SKILLS NEEDED FOR PHYSICS AND DEVELOPED BY PHYSICS

Khalijah Mohd Salleh
Physics Program
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
43600 Bangi Malaysia
khalij01@pkrisc.cc.ukm.my

Abstract

Based on practices of successful physicists, a set of skills used by experts when doing physics were determined. These set of skills were then checked against the skills that students of physics can develop and acquire in the course of their studies starting at school level. The paper however points out that skills for physics may be the same for all physicists but skills by physics vary depending on whether pupils are learning general or pure physics. The paper further points out that the nature of skills for physics are not static but change with time due to .the advancement of scientific knowledge and technology. Some comments are made regarding the way physics skills are acquired by experts and novices.

Introduction

For this paper, skills needed for physics has been arbitrarily defined as those skills that practicing physicists or the experts have in conducting physics activities primarily in research and development either in academic institutions or research institutions. Similarly skills developed by physics refer to those skills that students or novices would end up having after undergoing learning and training in physics.

To determine what these skills are, there is a need to review the meaning of the word physics. The popular meaning is physics as a science of matter and energy. In a physics textbook (Serway 1996), physics concerns concepts and principles, problem solving, and experiments. But skills for the development of physics implicate more than just concepts, principles,

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International Year of Physics 2005

In 1905, Albert Einstein published his three epoch making papers on the *Special Theory of Relativity*, *Photoelectric Effect* and *Brownian Motion*. To commemorate the centenary of that year, at the suggestion of the International Union for Pure and Applied Physics (IUPAP) and UNESCO, year 2005 was declared the International Year of Physics (IYP) by the United Nations General Assembly.

Underpinning this landmark decision is the felt worldwide need to –

- enhance public understanding of physics;
- emphasize the role of physics as the basis of many other disciplines and the incubator for newly emerging scientific and technological fields;
- emphasize the role of physics in developing countries and for development; and
- strengthen the teaching-learning of physics at all stages of the educational program and attract young talented students to consider a career in pure science, especially physics.

As nations across the world join the celebrations, it is the collective responsibility of those in physics to organize activities that meet the underpinning objectives.

The Delhi conference is a step in this direction and the flagship event of IYP celebrations in India. As an overview conference, it is expected to draw a very large number of participants from across the world.

Conference Objectives and Themes

The primary objective of this conference is to bring together physicists, physics educators, physics education researchers, curriculum developers and those engaged in training teachers for teaching physics on a common platform to share their experiences about the teaching-learning process in Physics, and thereby bring to the forefront the urgent need for enhancing the quality and effectiveness of teaching-learning programs across the board. Specifically, the conference would aim to present comprehensively issues and examples of praxis that highlight the following themes:

Changes in the ways of teaching-learning of physics

- Role of hands-on mind-on activities in the teaching-learning of physics
- Role of experiments and evidence in the teaching-learning of physics
- Role of mathematics in the teaching-learning of physics
- Role of ICT and new technologies in the teaching-learning of physics

Changes in the understanding of the teaching-learning process

- Current issues and findings in physics education research
- Building diagnostic tools and instruments for assessment
- Role of classroom research in enhancing the quality of teaching-learning
- Role of image of physics and beliefs about learning

Changes in the content of physics as a discipline

- Introducing the emerging areas of physics in the classroom
- Building a holistic perspective about the structure of knowledge in physics
- Connecting research in physics to teaching-learning of physics
- Teaching of physics in multidisciplinary contexts

Changes in the context of physics teaching

- Bridging the gap between schools, colleges, universities and the workplace
- Connecting the teaching-learning of physics t cultural contexts
- Nurturing the women in physics
- Enhancing the public understanding of physics in a modern society

It is hoped that a comprehensive exposure to seminal research and development work in Physics Education radically alter the pedagogic content of teachers' knowledge and the vision of teachers have of the teaching-learning process. The Conference presents such examples praxis and resource material that can be gainfully employed by physics teachers to enhance the quality of their classroom teaching and also enrich their professional lives.

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problem solving and experiments. Development of physics can refer to generation of knowledge, development of methods and techniques, instruments or equipments to conduct physics. It may also be associated with the needs of a country in which physics is regarded as a tool to development within the context of knowledge and performance based economy and society. Physics input has relevance to present day economic growth and development especially those related to latest findings of materials, techniques and approaches that have commercial potentials. There is also physics for defense and social development. Thus physics seen as a tool for national economic growth, security, environmental care and social development requires a complex management approach that involve experts from other disciplines which therefore must be necessarily collaborative in nature (Haythornwaite et al, 2003). This therefore means that physicists need to have other related skills like management and communication.

At the other end of the spectrum, we have the novices who may be at the primary level and secondary level or tertiary level. Novices are beginners in pursuit of learning physics. However it must be noted that at the primary or secondary levels of education, it is rather early to conclude that students learning physics will continue to learn physics and opt for careers in physics. In Malaysia in 1999 the proportion of students doing pure science at the equivalent O level was 28 percent of the total student population of the same cohort. (http://www.moe.gov.my/statistik/frinstat.htm). Of these 97 percent of them did physics. The rest of the student population is exposed to physics through the general science subject which is compulsory for them.

Physics skills developed by physics for the novices are different at different levels. For the school level, the focus is more on the skills related to the processes of science and simple problem solving. It is the curriculum board and qualified officers that determine the skills that these novices should have. Practicing physicists have occasionally been invited as consultants to such board during the time when curriculum is being developed. At the university level, it will be the analytical experimental, research skills and problem solving that will be emphasized. It is the lecturers and professors that design the curriculum through the curriculum committee of the department of physics. Those from the public sector and from the industrial sector are occasionally being invited to provide input so as to make the curriculum relevant to the national and industrial needs of the country. The curriculum is then assessed and evaluated by experts from either local or foreign universities. This is to ensure that the curriculum is of certain academic standing. What is it that is finally being offered to the students can be determined from the teaching and learning materials that are used by the instructors and the students.

Whether it is to excellent students or otherwise, and to the members of the public the perception regarding physics is about the same. Physics is perceived to be dull, dry and difficult for students right from school level. The pull towards physics is therefore negative. It is made worse when career prospects in pure physics are not as attractive as in professional areas. The goals of physics learning do not necessarily correspond with the goals of doing physics vis-a-vis understanding of physics concepts, discovering the laws of physics and developing the skills to do physics. What students learn in schools in the end depend on what is likely to be examined.

Skills needed for physics

Skills are practiced abilities that enable a person to achieve what he aims for. Skills affect speed of doing work, efficiency, and finesse of work. Skills for physics are developed by experts who are already interested, passionate, serious and committed to physics.

Physics skills by experts

Skills for physics can be determined from the types of activities carried out by the experts. We learn from the literature about how Archimedes intuitively discovered his Archimedes principle while in the bathtub. Tycho Brahe made detailed measurements of the planetary motion. Kepler used these measurements to determine the laws governing planetary motion. Newton was eighteen years old when during his eighteen months in rural seclusion "he conceived all the ideas for which the world is grateful (Gamow, 1961, p. 52). Newton investigated nature and cultivated mathematics (ibid, p.53), determined the laws of universal gravitation and invented a reflecting telescopes (New College Encyclopedia). Enstein, a renowned physicist of the 20^{th} century and known for his theoretical formulation of $E = mc^2$, worked on heat, electricity and light. He derived the detailed theory of Brownian motion, explained the laws of photo electric effect and expounded the theory of relativity (Gamow, 1961, p 171).

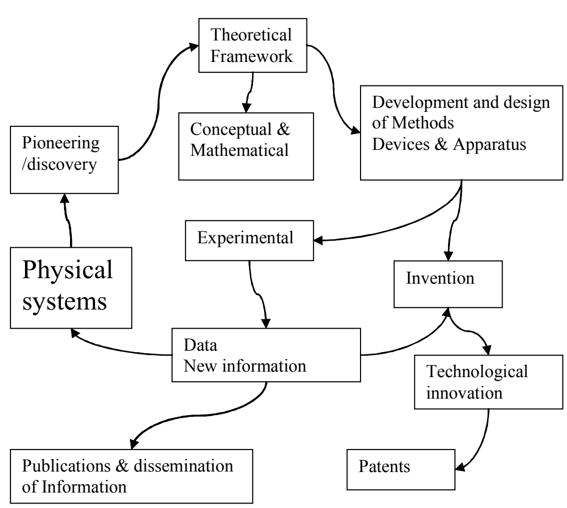
Physics among Nobel Laureates

Then there is a long list of other physicists and Nobel Laureates who have helped further develop physics to great heights benefiting mankind in various ways.

Starting 1990 till 2003 there are altogether 14 physics Noble Laureates (http://www.nobel,se/physics/laureates/index.html). The scope of physics covered and type of activities carried out were found to be (Figure 1):

1. pioneering contributions in superconductivity, astrophysics,
2. fundamental studies of the properties of condensates,
3. basic work on ICT to be uses in high speed optoelectronics
4. invention of integrated circuits,
5. elucidating quantum structures of electroweak interactions in physics,
6. discovery of new form of quantum fluid, development of methods to cool and trap atoms with laser light
7. pioneering experimental contributions to lepton,
8. neutron scattering techniques, neutron spectroscopy,
9. discovering of new types of pulsar
10. invention and development of particle detectors,
11. discovering methods to study order phenomena in simple systems
12. pioneering investigations in particle physics

Figure 1: Cycle of Physics



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Between 1990 till 2003 the areas of physics developed are superconductivity, astrophysics, physics of condensed matter, optoelectronics, integrated circuits, lasers, neutron spectroscopy, simple systems and particle physics. The nature of physics activities are pioneering, fundamental studies, basic, experimental, inventive, discovery, development of physical systems, techniques, methods, devices or apparatus. The spectrum of work therefore covers theoretical, experimental, and practical or applied physics.

Further exploration on the lives of successful physicists particularly among the Nobel Laureates showed that a number of them were editors of journals, directors of institutions, project leaders who organized group research activities, collaborated with various other research groups consisting of either academic professors or consultants. A number of them had been responsible in providing leading ideas and leadership in the conduct of their physics activities.

Scope of physics activities

Areas of physics activities as described in Kragh (1999) are being summarised in figure 2. During the time of Aristotle, Thycho Brahe and up till now, basic or fundamental research is top priority for the physicists. However needs of a given society at a particular time period influence the nature and type of physics activities carried out by the physics community. The benefits of physics are not for the physics community alone. Knowledge and findings of physics found applications in other disciplines like medicine and engineering. Right throughout history physics community has given assistance to the government, the industry and society. Research had been carried out in areas of military strength and defense. Research on semiconductors, lasers, condensed matter and lately nano and bio technologies have made the economic and industrial sector more vibrant and dynamic. Presently the scope of science hence physics extends into the socio-ethical-moral dimensions. Members of society are expected to be scientifically literate. This has implications to physics education particularly at the critical time when people are found to be disinterested to learn science.

Thus there are different levels of work in physics: the intellectual or knowledge and practical and technical physics at the individual and group level, the administrative at the organizational level, the communication of physics at the public level. Technical physics are the concerns of the physicists. They primarily focus on the physical system under study. These include the theoretical, experimental design and data taking, analytical and applications. Organisational activities refer to the establishment of laboratories, formation of research groups, management of research activities, resources, time and money. Social activities refer to the interpersonal interaction among members within and without research group. Finally communication refers to the transfer and dissemination of information to others. Note that at each level of activities there are specific skills that are required for the growth and development of physics; the intellectual, technical, organizational, social and communication skills.

Working culture of experts

Presently experts continue to improve, develop or upgrade further their skills through various means. First the organizational structure has evolved throughout these years. It provides the experts with the necessary material, social and moral support that they need. This makes the working environment more conducive. People are motivated to work. Experts have their own special groups. Members can consult and interact with each other either informally or formally at any time they want to. Through discussions and exchange of ideas individual experts reflect over their work. They then take the necessary action to enhance their skills. The experts write and present their work in seminars, conferences and workshops. These meetings provide experts with opportunities to subject their work, writing and presentation of ideas to scrutiny, check and balance. Even at the level of publication, papers are being refereed and edited before being published. Through these activities experts learn about limitations, weaknesses or mistakes. They get feedback. Such feedbacks in turn help experts to develop a sense of what is good and bad practices, of what is right and wrong practices. Experts work in accordance to the standards demanded of them by various assessment bodies.

With modern information communication technology (ICT), connectivity is made available to most experts and professionals. Distance is not a problem to them. Furthermore, experts are able to capitalize on the latest technology developed and new knowledge generated to further advance their knowledge and develop new technologies. The rate of development continues to increase by the minute as a result of such advancement in knowledge and technology. There are also other political and economic forces such as globalization, competitiveness and ISO standards that have in one way or another directly or indirectly influence the physics community to work towards enhancing the quality of work, products and services which in actual fact further enhance and refine the skills for physics.

The discussion thus far shows that individual capability matters. However, it also points out that experts have ample opportunities to sharpen and refined their skills. They work in an environment that provides them with the necessary social and physical infrastructures. Also take note that a number of these successful physicists had a jump start since they were young. They grew up in environment that was supportive and conducive for them to develop the basic cognitive, intellectual, and practical skills for exploration and discovery of nature. This is true especially those who were born of parents who were professional or academic professors.

Skills developed by physics

Skills developed by physics refer to the types of skills that students can learn and acquire in the course of their physics learning. There are four areas related to skills that students should acquire with regards to physics. First is the content knowledge base whose breadth and depth help develop students' sensitivity to what should be observed or given attention to. Second is the organisation of information which needs to be in a hierarchical manner with causal effect relationship. Experts organize their information in a systematic manner. They exercise logical reasoning. These practices make it easy for experts to remember the knowledge that they have acquired. Studies have shown that this is not true among students. (Brandsford, *et al.*, http://www.nap.edu/html/howpeople1/ch2.html). Third is

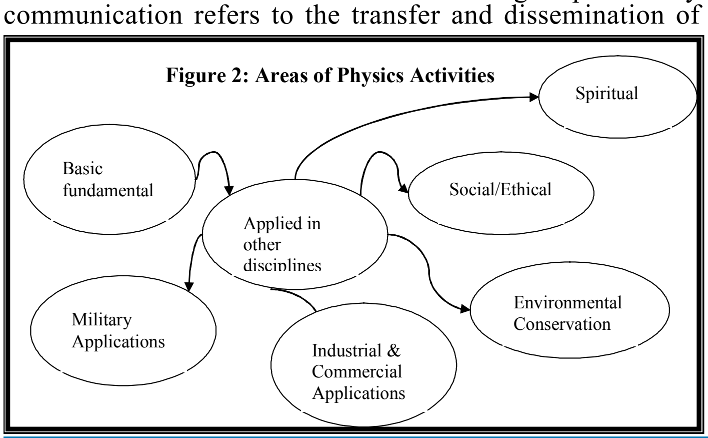

Figure 2: Areas of Physics Activities

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transparency of water - cannot be seen directly. Beyond the possibility to represent the material world, the painters exploit the many correspondences and allusions between mental reflections of the mind and light reflections of the water surface.

Fig. 3: William Turner: The Fighting Temeraire 1839. London: National Gallery

After analysing in detail the techniques William Turner uses to represent reflections on water surfaces, John Ruskin states: "There is more… than any philosophy of reflection, or any peculiarity of means can account for or accomplish; there is a might and wonder about which will not admit of our whys und hows" (Ruskin 1900).

The glitter path has been described for many times in many different situations by poets and writers, not only as an appealing phenomenon accompanying the sun set and as a projection of affections but also as a philosophical metaphor. The protagonist in a story of Italo Calvino, Mr. Palomar, notes during his evening swim: "When the Sun begins to go down, its reflection takes form on the sea: from the horizon all the way to the shore a dazzling patch extends composed of countless swaying glints; the sun's reflection becomes a

Fig. 4: Vincent van Gogh: Starry night over the Rhone. Paris: Musée d'Orsay 1888

shining sword in the water stretching from shore to him. He swims in that sword . . ." But what about the other swimmers at that time of the day, are they swimming in the same or each in their own sword? Where is the sword situated, everywhere or nowhere? "The sword is imposed equally on the eye of each swimmer; there is no avoiding it. 'Is what we have in common precisely what is given to each of us as something exclusively his?' " Palomar reflects on the light reflections: "Perhaps it was not the birth of the eye that caused the birth of the sword, but vice versa, because the sword had to have an eye to observe it at its climax." Finally "he has become convinced that the sword will exist even without him" (Calvino 1985).

Reading this text students may be interested to find out if the peculiarities, especially that the sword is always directed to the observer, may find a sound physical explanation.

Physical reflections on the light reflections

The glitter path is due to the reflection of some light source. Normally, this is recognised even by younger students. But how is the light forced in such longish shapes?

Starting from a flat surface only one reflection (at the point P in Fig. 5) hits the eyes of the observer. In order to receive light from other points of a plane

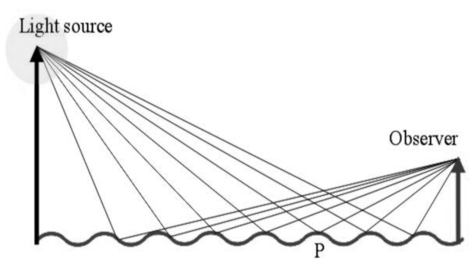

Fig. 5: A wavy water surface contains many inclinations from which light originating from the source is reflected to the observer.

there must be a suitable inclination so that the angle of incidence equals to the angle of reflection. The more distant those points are from point P the larger must be the inclination. Therefore, given a distribution of slopes below a maximal value, reflected light can only be seen within a certain area around P the extent of which increases with the maximum height of the waves. Apparently, the frequency with which the slopes change suffices to give the impression of a nearly continuous lit area to our eyes, apart from some fluctuations of the intensity – the glittering. Thus, the glitter path is the ensemble of countless reflections of some light source at suitably tilted water waves.

The extension of the glitter path can be estimated by simple arguments. As can be concluded from Fig. 6 the aperture angle is just 4 times the tilt angle of the waves.

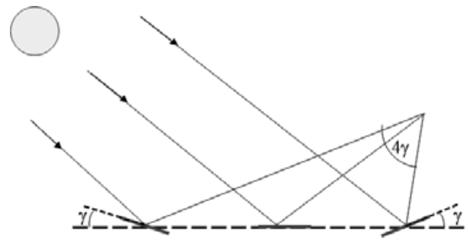

Fig. 6: The more the waves are inclined, the larger the area of possible reflections may be.

The calculation of the boundary leads to a curve of 6^{th} order and shall not be given here. Instead, we sketch the algorithm of a computer simulation for the shape of the glitter path. Given are the maximum slope of the waves and the heights of the light source and the observer. Representing the water surface by a blue coloured plane for each point (pixel) between light source and observer the slope necessary to reflect light from this point into the eyes of the observer is calculated. If the calculated slope is less than the maximum slope the point is coloured yellow, if not it is left unchanged.

As the observed shape of the glitter path is affected by the perspective, especially in the case of the low sun, the corresponding change was included in the program. For instance, when the sun is low the light band seems to have the same width all along the path. As one knows e.g. from the rails of a railway track, which converge towards the horizon, this means, that in reality the light path broadens towards the sun. Indeed, if this situation is calculated without taking perspective into account one gets a kind of triangle.

A very simple experimental approach to the glitter path is sketched in Fig. 7. A tilted mirror the slope of which

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can be adjusted to different values and which has a pen on its bottom side can be moved along the boundary, thus plot-

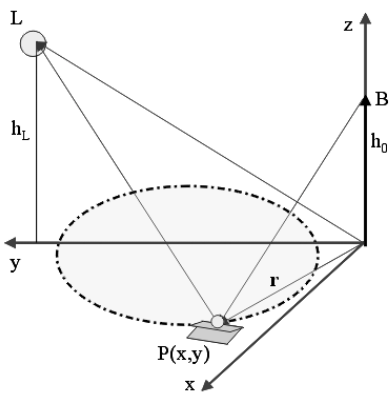

Fig. 7: The boundary of the area lighted up by reflected light depends on the heights of the light source L and the observer B and on the maximal slope of the waves

ting it on a sheet of paper. This can be done by looking through a small hole at B and controlling that the image of the light bulb L can always be seen in the mirror. The area surrounded by this curve can then be compared with the bright area calculated by means of the computer program (See Fig. 8).

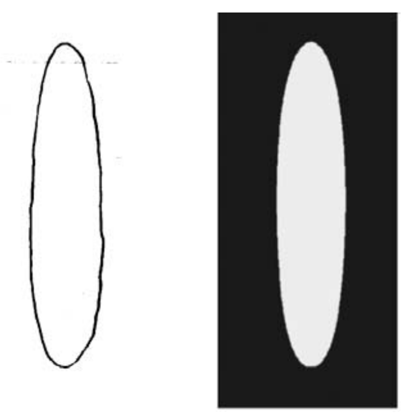

Fig. 8: Left: Plotted boundary. Right: Calculation of the reflecting area of the same situation.

The glitter path is not restricted to wavy water surfaces. Looking e.g. at a plate of glass lubricated by some grease, we can observe light paths of different shapes just by looking on it from a suitable angle.

The glitter path is a specular reflection phenomenon. Therefore, in many cases, especially at short distances, the many times reflected images of the light source can be seen in the water below the surface like a reflected picture behind the mirror.

As is well known from other reflection phenomena, e.g. the rainbow or the "heiligenschein", each glitter path is unique therein that it "belongs" to the observer. Due to the physical fact, that only those points of the rippled surface appear lit by the light source which – according to the law of reflection – had an appropriate slope, the location of the "sword of the sun" depends crucially on the observer's position. This explains, why Mr. Palomar saw the sword always directed to him.

Ubiquitous glitter paths

Light paths are not only detected on wavy water surfaces. On a rainy day the head- and backlights of cars draw beautiful light beads on – respectively: in – the streets (see Fig. 9). The fact that streets are not

Fig. 9: Light swords pointing into the wet street.

smooth but slightly irregularly rippled brings about a similar situation as on the wavy water. Under certain conditions it is even not necessary that the surface was wetted. For instance, smooth floors which have been grated by use can be excellent displays for glitter paths (see Fig. 10). But also surfaces, which look perfectly smooth, like table tops, metallic plates or lids (see Fig. 11)may show light streaks when displayed at a light source (at best a point source) and thus reveal tiny scratches which cannot be seen by the naked eye. These scratches fulfil the same function as the waves on the water in that their varying slopes provide for appropriate angles to the light

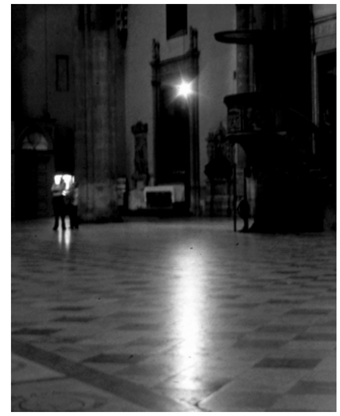

Fig. 10: Light streak on the tiled floor of a church.

to be reflected into the observer's eye.

To derive the structure of the surface by examining the form of the light paths correspond in some respect to methods of surface science, where the microstructure of surfaces is investigated by analysing the reflected "light" (not necessarily visible: X-rays, electrons) of a known source.

The more our eyes get trained to detect light paths in the everyday life world the more subtle become the phenomena, which will be recognized as such.

The well known light streaks appearing on records which bend in various shapes when viewed from different angles. This phenomenon emerges as well on compact discs, where the white light splits up in spectral colours due to the interference phenomena which become important at this dimensions.

Fig. 11: Light paths on a lid deformed due to the curvature of the surface.

Until now we only took into account light paths due to reflection. Transparent plates may also display light streaks when looking through it at a light source. For instance looking through the window pane of a bus or a train to a distant light source

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the representation aspect of physics information. They can be in the form of text, diagrams, mathematical equations or graphs. Finally, it is the ability to determine principles that can be used to solve problems. The skills associated with these are cognitive skills. Apart from these cognitive skills, students are also required to have skills to remember, reason and to apply knowledge for problem solving.

Physics and the students

Students are novices and the practicing physcists are experts. As experts they have the theoretical or experimental knowledge content and the skills to conduct physics. This is not true of students. At the motivational level, physicists are internally motivated to do physics. They are curious and have the desire to study and to discover various phenomena demonstrated by physical systems. They take it to be their responsibility to explain the phenomena that they observe. They enjoy doing physics.

Majority of students do physics simply because they have to. Physics is made compulsory to those who want to continue their education in science. Elements of physics have to be introduced in general science subjects. To the policy makers this is a prerequisite to develop a sustainable knowledge-based society who can benefit from the advancement of science and technology. It is believed that members of a knowledge-based society can make informed decision regarding health, nutrition, environment and safety, whether at individual or collective level. With survival skills, they can also benefit from the presence of technology to manage and administer more efficiently and effectively their everyday living. As the country advances further, civic participation, both at the individual and collective level, is required. People cannot be empowered unless they are scientifically literate. Failing to do that, they become marginalized from mainstream developmental activities.

Unfortunately, majority of students' perception towards physics has been more negative. The declining physics enrolment, a world phenomenon, is a testimony to this. There is already this inertia that blocks students' readiness and eagerness to learn and to do physics. They are probably not too passionate about physics. Thus, they are not wholly devoted nor too motivated to learn the subject matter. Furthermore, experiences have shown that many young people do not want to become scientists working in research laboratories. There are more interesting and challenging careers like in the industrial sector, or less technical like creative science, science communication as in science centres or careers in the media. Surely the types of skills that are needed by these various groups differ. Some may just need the basic skills of physics like making observations and measurements and they do not need the sophisticated mathematical skills of theoretical physics.

Science camps

There are already several initiatives undertaken by different groups of people to promote public awareness of science. Through activities of the programs participants are given the opportunity to be exposed and to develop science skills in particular physics skills. In Malaysia, science camps are getting more and more common. These camps are organized by the National Science Centre of Malaysia, PETROSAINS or sponsored by multinational corporations like BP or Shell. Through the science activities participants, primarily school children, learn to develop their skills. There may be about hundred participants for each camp. It was observed (Norli, 2004) that participating children, ages of 10-12, were ever curious, asking lots of questions and able to carry out the tasks asked of them. Examples of activities include moving a straw along a string using expiration of air from a balloon and testing the strength of a bridge built from chopsticks.

Skills required for knowledge workers include R&D skills, decision making, analytical techniques, management skills and strategic thinking skills (Akademi Sains Malaysia, 2003). School children (13-17 years old), attended by researchers during a science camp, showed an overall 63.2% in mean score on environmental knowledge and attitude (Syamsul, *et al.*, 2002). National science camps have succeeded in improving student's knowledge. Through activities the level of knowledge has increased by more than two-fold.

A colleague of mine told me of her experiences conducting science camps for young children ages 7-10. Several physics activities were given to the children like using match sticks to construct the strongest structure and playing with water ballooons. According to the colleague, she became just so fascinated that more than 80% of the children were having great fun doing all the activities. They were full of curiosities. They asked a lot of questions. They were free to explore their activities. Give children opportunities to carry out activities in a challenging manner, they would be bound to take up the challenge. To her, it is the environment that influences the type of children that they grow up to be.

Science competiton

Another situation is students doing physics project for competition (Report, 2003). There were all in all 121 projects of which 22 were from physics. With a maximum scale of 1, the projects were assessed for the following criteria: working together (0.70), clarity (0.68), creativity (0.67), and scientific thinking (0.66). It was found that the best performance was from biology followed by engineering and chemistry. It turned out that those from biology had research scientists either from academic or research institutions as their mentors. This really showed that given the opportunity, students could develop skills that correspond with those of the experts though not at the level of the experts.

Issues in learning physics

There are several issues related to students learning.

Skills in giving descriptions and explanations

Observations showed that students had difficulty in describing the phenomena, *e.g.*, a ping-pong ball was dropped onto the floor from a certain height. Students were asked to observe and record what they saw. Not many students described how the ball hit the floor, reflected, moved up, reached a new height but at a lower value compared to the initial height, and this happened several times before the ball finally stopped moving. Students tried to provide explanations like it fell due to gravity, and that there is a loss of potential energy and a gain in kinetic energy. Probably students do not have a clear idea of what the words 'describe' and 'explain' mean. Skills by physics should help students know what are expected of them when they do physics. Students should be able to describe the phenomena based on what is visibly happening. Then they should see the nature of the physical phenomena, what factors or variables affect the phenomena. Then they should see how variables are affected by one another, establishing the hypothesis.

Learning skills

Students' forum at a Malaysian educational portal website revealed that school students had several questions regarding how they learn their physics and other science scores. (http://www.cikgu.net.my/malay/forum/forummat.php3). Several statements regarding learning were found in the forum section:

> *Suggestion*: it is easy to score full marks for science and mathematics. Just memorise the formula and main content. Before test must do past questions.
> *Problem*: Since I join form 1, I find maths

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GLITTER... *from page 7*

this source may appear endowed with a long straight almost vertical light beam. The beams are not caused by reflection but by refraction of the passing light at an array of parallel tiny gratings on the panes oriented orthogonally to the light beams. Due to the transparency and invisibility of the panes the light beams are not associated with the panes but with the light sources. The origin of the gratings may be e.g. grooves caused by the rotating brushes of the cleaning machines.

Looking through the front shield of a car at a light source one may detect light streaks similar to the reflection beams of a record. Circular gratings caused by the action of the windscreen wiper are the reason.

A rather peculiar class of light paths consists of short light tracks which seem to form concentric circles around the image of a reflected light source on a smooth surface (see Fig. 12). In a strict

Fig. 12: Circular light rings around the image of a reflected light source on a spoon.

sense the surface is not smooth but has invisibly small grooves or scratches. If there are many scratches and if they are randomly distributed there will be always short sections of it exhibiting a suitable range of slopes for the light being reflected into the observer's eye. For symmetry reasons the sections of the same slope are oriented along a circle around the reflected image. The extent of the illuminated area depends on the angular range of the scratches. Normally, the origin of the randomly oriented scratches is due to abrasion by daily use. A corresponding phenomenon can be observed when light shines through a grated transparent plate. The light is refracted at randomly distributed scratches giving rise to similar circular light pattern as in the case of reflected light. Light sources regarded through an airplane window, in most cases, appear surrounded by circular oriented illuminated light lines.

Fig. 13: Circular light rings on an airplane window.

Summary

Starting with the glitter path as a common natural phenomenon which has attracted special attention, especially by painters and poets, it has been shown, that there are also interesting physical aspects.

From a physical point of view the glitter path is both simple and complex. It is complex inasmuch the shape of the reflected light trail is not related in a direct way to a specular reflection of the sun. It can be shown by simple hands-on experiments at least qualitatively that the glitter path may be conceived as a composition of many tiny mirrors irregularly distributed on the water plane. The mirrors are made up by the slopes of the waves.

Against the background of this approach the observer is prepared to detect "glitter paths" in many different ambiances, as e.g. the headlight of a car reflected on the wet road or the light bands of a street lamp in a water puddle. Finally, even light paths on totally dry grounds, e.g. on a tiled floor or even those light streaks apparently attached to light sources looked at through transparent media may attract attention.

The problem of explaining complex phenomena within an every day life situation is in most cases not as much due to the complicacy of the physics behind it but due to the difficulty to recognize and to elaborate physical aspects in a non-physical context.

Although the physical explanation represents an extreme reduction of a complex, multiperspective phenomenon to the simple law of reflection or – in the case of transparent plates – to the law of refraction, this must not necessarily be experienced as a disenchantment. On the contrary, the physical perspective may intensify and enrich our view and thus contribute to detect further interesting related phenomena.

Moreover, according to our experience, both the esthetical effect of the phenomena and the satisfaction of the learner felt in successfully elaborating a complex problem are a source of a high motivation.

Presented in a poster session in the International Physics Education Conference in Durban, South Africa on 5-8 July 2004.

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is getting more difficult to understand because it has been changed into English and now my maths is getting worse. Can you help give some tips.
Response: you should understand the concepts that are going to be taught first. Discuss with the teachers. Memorise the formula and read reference book in Malay. If you don't understand then ask the teacher.
Problem: I cannot follow the lessons in additional maths, chemistry, physics and biology. It's difficult to target science subjects. Please help how to score.
Response: Science is something that happens around us. It needs understanding in a given topic. Ask teachers or parents if you don't understand. Once understood, do some experiments and memorise. Science is easy if we really understand. It is not difficult if we always study, revise and most importand, understand one by one what is to be expressed. Everything is related to common sense that happens in everyday life. If you really study, it is not surprising that you will say science is very easy. Best of luck in trying.
Response: Read and understand, then memorise what is required. Do mind mapping. If lazy, do it in the head. Visualise until you get clear picture of the scientific processes in the mind. Study not to score but to understand. If you still want to target then do past questions.

It was not clear whether these mails were from the teachers or the stduents. However, analysis of the comments made pointed out several things. Physics is learnt through memorization of tips and formula, and practice of past examination questions.

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Students are aware that understanding is needed. This can be achieved by doing experiments. However, they still have to commit to memory what they have understood. For some it is common sense as it happens in everyday life. So all that needs to be done is do mind mapping until the processes are clear in the mind.

The replies given are mixed. There are those who will just want to learn the formula and those who strive to understand. But what is missing is some guide of what one should actually look for when one is doing experiments.

Teachers' preparedness

Skills by physics to be developed at school level are done by teachers. What has to be recognized is the fact that in schools there are physics teachers who do not have the background hence qualification in physics. No doubt these teachers have pedagogical knowledge content but their knowledge of the subject matter may be limited. No doubt we have to thank these teachers for their help to ensure survival of physics, but it has to be recognized that there is a limit to their understanidng of physics work culture. Furthermore in schools teachers have no way of overcoming the exam-orientedness of the school system. The demand to complete the syllabus is always there. There is also the external pressure set by parents on schools that in the end ideals of learner centeredness in education is just a dream rather than a reality.

Physics experts-teachers gap

It is the community of physics that determine how and in what direction physics activities are to be conducted and developed. The physics experts and the teachers are not really in touch with one another. The situation is made worse when the linkage between teachers and experts is weak. The experts are more into physics than into education. So teachers lack the opportunity to be within the physics environment. Being detached from the physics work culture prevent teachers from being fully conscious of nature of physics and hence lack the true spirit of practicing physicists. Teachers particularly among the non-option physics teachers, therefore develop their own view of what physics is all about. Pressured by the exam-orientedness of education, classroom teachers are induced to concentrate on completing the syllabus that it is not possible to completely student-centered. Physics learning boils down to acquisition of facts rather than training for the development of cognitive skills needed for knowledge understanding and content acquisition, mathematical skills needed for practical and theoretical work, and skills needed for development of the right attitude towards physics and the learning of the subject matter.

Experts vs. novices

Students are different. Physicists have one thing in common, *i.e.*,the love and the dedication to do physics. Students may not show the same feeling for physics. In the learning of physics or whatever subject for that matter, the psycho-emotive, motivation, social and cognitive dimension of growth and development cannot be ignored. It is the psychological cognitive interaction with the socio-cultural influence that affects students' readiness to learn physics. At the level of the novices, teaching of physics cannot focus just on facts and practices of physics but also the psychosocial dimension. So this means that teachers need not only skills of physics but skills to motivate students to be interested in physics and be able to learn physics.

Situated learning

Knowledge and learning are situated (Brown, *et al.*, 1989). Learning methods that are embedded in real situations are not merely useful but needed. Students from the Centre of Applied Science Universiti Kebangsaan Malaysia went for an industrial training programme for eight weeks. They were placed in hospitals at the x-ray units, the padi factory and Standard Industrial Research Institute of Malaysia (SIRIM). As the students' academic supervisor, I visited the students at the various places. What stood out was that they really enjoyed their learning experiences. This is simply because it was hands-on, minds-on method of learning. Whenever they could not understand anything, they felt free to ask and what they liked was that they could get the answer immediately. Futhermore, their learning was accompanied with situ demonstrations. When they have problems in understanding what the instructor told them, they could question immediately and get the answer there and then. On top of that, their understanding was supported by actual demonstration of the work that they did. But what is obvious is the acquisition of skills when trainings are conducted by the experts in the real environment.

Implications towards classroom instruction

Not everyone who does physics wants to end up in the physics laboratory to research in physics. About 10 % of the total population of physics students would want to pursue careers in physics research but the rest may want to enter physics related field; education both formal and non formal, industry, mass media or even management. Those intending to go into research may require high level computational skills but those who want to go into management need to know something about management like system thinking. How can diversities in background and career inclinations be handled? Less than fifty percent of students enrolled for 1st year physics this session at my university actually chose physics as their first choice. These students are not as motivated as those who chose physics as their first choice. They may not have reached the desired cognitive skills to learn physics on their own. So how do physics lecturers who are subject specialists handle these students who may be cognitively handicapped to learn physics on their own? This will be a great challenge for the lecturers. Students enjoyed hands on minds on learning approach. Whenever they have problems they are not afraid to ask as they get immediate feedback. Present curriculum that is content laden, examination driven hence may not have given serious attention to skill development training. Skills development needs training. This needs time. Lecturers, instructors or teachers have to be provided with the right teaching learning environment if they are to provide students with activities that develop their conceptual and reasoning (ASPEN Proceedings, 1995) skills.

Conclusion

In the past learning is meant for the elitist group. However for 21st Century, it is science for all. cognitive skills. Furthermore attitude affect students' motivations towards learning. Therefore teaching must be done in a way that take care of students' interest and readiness to learn. For skills to be developed teaching must be done in a way that moves the students' hearts and minds. Teachers need to facilitate the development of skills and that opportunities to practice need to be given similar to what experts are experiencing. Rather than saying that it is students who do not know this or that it would probably be better to find out how instructors or teachers can improve their communication skills and art of delivery so as to make students cognitively alert and effective.

Paper presented in the International Physics Education Conference in Durban, South Africa on 5-8 July 2004.

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ICPE Chair's Corner

The summer of 2004 was an interesting one from the point of view of our commission C14. For the first time ever our annual meeting was held in an African country, namely South Africa. It took place just after the conference, "What Physics Should We Teach?", arranged jointly by the South African Institute of Physics and our commission. The main organizer was one of our members, Diane Grayson from the University of South Africa. About 70 participants discussed topics centered around seven strands: *Overcoming fragmentation in physics, Blurring the boundaries of physics, Different strokes for different folks, Origins and ways of knowing, Skills, Conceptual organization* and *Physics for today*. The venue was the University of KwaZulu-Natal in Durban. The structure of the meeting was carried through in a very systematic way, with, in order, a plenary talk in the beginning of a morning or afternoon session, followed by small-group discussions on the topic of the invited lectures. Then each session ended with a period of guided posters, mostly of very high quality. However, some concern was expressed with regard to the small number of attendees and the lack of physics teachers among them, especially from other African countries.

The annual meeting heard reports by the chair about the physics competition, *International Young Physicists' Tournament*, which this year was arranged in Brisbane, Australia, and gathered a record number of 26 teams from 24 countries. Considerable time in the meeting was devoted to discussions about next year's conference with ICPE involvement, namely the one in New Delhi in August 2005. "**World View on Physics Education in 2005: Focusing on Change**." The main organizer, our ICPE member, Pratibha Jolly, reported on the progress in the planning. This conference will also, to some smaller extent, serve as preparation for the IUPAP "**World Conference on Physics and Sustainable Development**" to be held later in 2005, in Durban.

The ICPE book "Physics Now" has now been printed and will be available from November of this year. At the annual meeting of ICPE our associate member Minella Alarcon reported an interest from UNESCO to acquire this book, for distribution to various interested partners in the world. Since there has also been a request from India for a number of books, the edition will comprise 2.500 copies already in the first printing. Our thanks should again be expressed to the editor, Jon Ogborn, for his work with collecting the contributions and for writing the C14 chapter, as well as to Pratibha Jolly for setting us in contact with the Indian printer.

Further, reports were given for physics education activities in Latin America, where seven countries organize a network with the aim of improving physics education in secondary schools as well as preparing teachers for this level. Also EPS, the European Physical Society, is going to start a series of physics education conferences; the first will be held in Bad Honnef, Germany, next year.

Next year's annual meeting will be held just after the 2005 conference in New Delhi.

Professor Gunnar Tibell
ICPE Chair

Citation for the Presentation of the ICPE Medal to Professor Laurence Viennot

Université Paris 7, France

Laurence Viennot has a distinguished international reputation in Physics Education (Didactics of Physics). She has been invited to lecture and give courses in the USA, Canada, Argentina, Brazil, North Africa and Russia as well as in most European countries. Her work is highly reputed for its integrity, careful attention to detail and its close relationship to practice as well as for its vision and for the depth of the underlying thought.

From the time when she presented the very first doctoral thesis in physics education in France, Laurence Viennot has played a leading role in establishing physics education research both in France and internationally. She has adopted a distinctive approach to the subject, in which links to the discipline of physics are kept strong and integral. Significantly, her work has commanded the respect of many physicists.

Nationally, Laurence Viennot played an important role in the formation of curriculum changes and the introduction of new courses. She was influential as a member of the Physics group of the National Committee of Programmes of the Ministry of Education,

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The ICPE medal was presented to Prof. Laurence Viennot by Prof. Gunnar Tibell, ICPE Chair, in the International Physics Education Conference in Durban, South Africa on 5-8 July 2004.

Contributions to ICPE Newsletter

Physicists, physics professors, lecturers and teachers, and physics education researchers are invited to contribute to the ICPE Newsletter.

Contributions may be: news of physics education activities, seminars, conferences; research articles; write-up of unique student experiments/investigatory projects; description of teacher demonstrations, improvised equipment and accompanying student experiment; book reviews; and novel physics problems and test items.

Text (including pictures) of contributions is limited to 1-3 pages, single-spaced. Your contributions should reach the editor by mail or e-mail, at the latest by **end of February for the April issue or end of August for the October issue.**

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of the Commission of the French Physical Society, and as an expert for the Ministry of Research. Her insistence on basing proposals for reform on sound evidence, and on careful evaluation of the results, was central to these policy involvements.

Internationally, Laurence Viennot has a very strong reputation in a wide range of countries. Her influential books have been translated into English and Spanish. Her extensive publications in international journals have reached a wide and multilingual audience.

No less important has been her personal influence, on her own students and on many senior researchers in Physics Education worldwide. She has shown by example how to combine intellectual caution and modesty, never overstating results, with a wide ambition to address deep and important issues in the teaching and learning of Physics. The concreteness of the results is matched by the imaginative grasp that lies behind them. She has a very special talent for choosing a good problem: one that is both soluble and important. Over the years Laurence Viennot and the colleagues she has led and collaborated with, have helped build the reputation of Physics Education worldwide.

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Visit the ICPE Homepage: www.phys.ksu.edu/icpe

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For comments, questions, or to be added to or deleted from the mailing list, please contact the editor:

***Editor*:**
DR. VIVIEN M. TALISAYON
University of the Philippines
College of Education
Diliman, Quezon City 1101
Philippines
Tel. & Fax no.: (6 32) 929-9322
e-mail: *vivien.talisayon@up.edu.ph*

The International Newsletter on Physics Education is a bi-annual publication of the International Commission on Physics Education.

***Editorial Assistant & Lay-out*:** Jocelyn Rose C. Ilanan