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Teaching and Learning of Physics Education in Cultural Contexts

The main theme of the upcoming ICPE-sponsored international conference on physics education is Beyond Classrooms into the 21st Century: Teaching and Learning of Physics in Cultural Contexts.

The conference will be held in Korea National University of Education (KNUE) Cheongwon, Chungbuk, Korea on August 13-17, 2001. The main conference topics are: Physics Education from the Past; Physics Education for Living and Fun; Physics for the Public; Physics Education with High Technology; and Physics Education into the 21st Century.

China, Korea, and Philippines E-Linked in Physics Education

Three institutions in Korea, Philippines and China tried an e-linked course as an International Commission on Physics Education (ICPE) Project of three members. Seoul National University in Seoul, Korea, the National Institute for Science and Mathematics Education Development, University of the Philippines in Metro Manila, Philippines, and Guangxi Normal University, Guangxi, China participated in the project. Graduate students, physics teachers and university faculty interacted via the Internet on November 4, 11, and 25, 2000.

The topics and faculty facilitators were: Curriculum Development in Physics Education - Prof. Vivien M. Talisayon (Philippines); Differentiated Approach in Teaching Force and Motion - Prof. Pak Sung Jae (Korea); and Hands-on Experiments for Enhancing Learning - Prof. Luo Xingkai (China).

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In This Issue

Physics Beyond 2000: New Curriculum for a Better Physics Education

This round table in the GIREP-ICPE International Physics Education Conference in Barcelona, Spain in August 2000 aimed to provide the participants opportunities to discuss about the following issues: (1) How should physics be taught, (2) What specific areas should be included in the new physics curriculum, (3) What specific areas should be retained in the old physics curriculum, (4) How do we integrate science education research results with everyday school (academic) activities?

J. Ogborn from United Kingdom, J. Yingprayoon from Thailand and V.S. Varma from India, are among the discussants. R. Gutierrez, from the Science Education, Fundacion Castroverde, Madrid, Spain, was the coordinator.

Helping someone to learn how to teach well is more easily done than said, and the process is more of an apprenticeship As Picasso put it, 'What I do not know how to do, I learn by doing.'

Physics Beyond 2000 and Science Curriculum

by Jon Ogborn
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What's the problem?

The problems to be addressed are the mismatch between the science and technology courses offered in the curriculum and the needs and concerns of those who are obliged to study them; there is a need to deal with the fact that science and technology, taught to many, are only practiced by a few.

Knowing science in order to value it

What claims can be made for science in the school curriculum? The achievement of the sciences over the past three or four hundred years tell us important and interesting new things about ourselves and the world we live in. Its special character is to offer knowledge that can be relied on. This reliable knowledge is also more than a compendium of things that have been observed, it presents the world under quite novel guises, i.e., in reality, things are often not what they seem to be.

So powerful is the impression of some people that scientific knowledge has been thought of as the only true knowledge, that a large number of things in the world could not be understood in this way. Thus, there is a need for people to learn about science, both to participate in a culture to which it substantially contributes, and to be aware of the scientific traps of over-estimating it.

This way of thinking about science in education - entailing knowledge to be known sufficiently in order to have value - also helps us avoid an insidious trap which ensnares much educational thinking and school practice. Pupils pass hourly from one subject to another, and (after the primary school) each teacher of each subject seems to be charged with the duty of saying: "Be like me!"

Teaching *about* science

A good part of science education for everybody is teaching *about* science, not doing science. There is another venue for the latter, since a way to develop an interest on the value of an activity is to try doing something which models it. But it does mean giving up the notion that we are teaching most pupils "to be scientists or to be scientific."

It follows that a good part of science education has to be devoted to popularizing scientific knowledge and to giving accounts on how that knowledge was established.

A common idea is that the task is to provide through experiment and demonstration, evidence which establish an idea, so that pupils may be rationally convinced of the correctness of the ideas being taught. Learning is the same as rational conviction. The prejudice against telling scientific stories about the world without showing exactly what justifies them means that we defer, usually until much too late, some of the more interesting and fundamental ones. One way to get used to the ontological zoo (the inhabitants of scientific worlds) is to hear stories which involve its inhabitants. And this is also a way to grasp what is involved in scientific explanation: departing from common sense explanation, in seeking to explain, could be considered as common-sense. Of course such stories must raise the question: "Who could believe such a thing?" It is not always necessary though to offer the grounds of belief before describing what people believe.

Technical competence and know-how

A dimension of equal importance is that of technical competence and know-how. It is central to the scientific culture that it is a culture of action and doing. Its action in the world sustains its realism. Besides the practical benefits of being able to join in a do-it-yourself spirit in the technical culture is the importance of the values - pragmatic and aesthetic - of being able to do things well. The key here is the development of rational confidence.

Science provides crucial know-how about ourselves and our bodies - knowing how to maintain health, how to avoid diseases, and how to cure or treat minor complaints or injuries. There is valuable know-how about how to treat animals and plants - caring for them and getting benefit from them. School science ought not to be more of little petcare and gardening, and where possible some farming. Know-how about the conservation, preservation and sustainability of the environment, e.g., making shelters or purifying water, should be taught and learned in science education.

The science curriculum

For science curriculum to be attractive, it needs to focus on questions which are of importance and interest to people. The curriculum has to provide opportunities for experiencing a good variety of science methods and techniques, particularly important ways of being rational about the world.

By no means, all scientific world-pictures interrelate with fundamental basic human concerns. There can be no pretence that science is designed just to answer various questions we all want to be answered, while in fact it is designed instead to answer those questions which can be answered. Scientific knowledge touches broad human concerns, under five themes:

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life: where it comes from
matter: how it changes
the universe: how it is made/formed
the made-world: how things are made
information: how communication leads to information

These are all areas of potential interest to many in which the sciences have something fundamental to say. Together they display a good deal of scientific ideas and concepts.

Another essential reason to address questions of importance to people is to motivate them to the necessary task of describing the "ontological zoo" of science. To them, the inhabitants of the zoo seem strange, so it is right that they are shown to play an important part in stories which explain something about who we are and where life came from, what the stuff of the world is like inside, how the universe is built and how it may have begun, how we have the physical world around us, and how transmitted and reproduced information underlies both communication and the nature of life.

Finally, if we address questions which matter, and not just questions we can answer, we will be open to confront the limits of scientific knowledge, and to consider what value to give the scientific knowledge at hand as well as that being discovered.

The laboratory work should form the backbone of the physics course. The experimental work should aim to bring clearly before the pupil the physical meaning of laws and processes, and enable him to organize and apply such knowledge.

-- How to Teach Physics, Rogers D. Rusk (Lippincott, Philadelphia, 1923)

Physics Beyond 2000: A View from India

by Vijaya Shankar Varma
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Education in India is an engine for social transformation. It is the only way that children who are born from the underprivileged sections of our society can be empowered to win greater opportunities in their lives and also be better informed citizens of tomorrow. This is their only means for social mobility. Universalization of access to quality education and retention of children in school is therefore the greatest challenge facing our country. Any educational reform that we undertake, any new curriculum that we develop, must therefore contribute to the school, making it more attractive, more interesting, more relevant and more empowering to children. It must teach children how to learn so that learning becomes a life-long activity. It must pay special attention to the needs of girls because they are the more disadvantaged; they are the ones who are forced to drop out of school because of social and economic reasons.

These reforms, which are desirable for the educational system as a whole, must also include decisions not only about what science is taught but also how it is taught. At present, science is taught in our schools as a body of complete knowledge and as a discipline that offers answer to all questions that are worth asking. It also insidiously implies that all problems are amenable to the scientific enterprise. It is important that school science free itself from such a paradigm. It is important that we teach science not in a way that it always provides the correct answer. It should be realized that there can be situations, particularly at the science-society interface, where it is often impossible to get an unequivocal answer. In real life, choices have to be exercised, different possibilities have to be weighed out -- particularly when the well-being of the community is affected by such decisions. Should we or should we not build big dams? Should we use nuclear energy to generate electricity? How much chemical fertilizer should we use? Should pesticides be banned because they are also harmful to human health? Should we pump water for irrigation at the risk of depleting our ground-water resources or should we be content with lower agricultural yields? The major question is how do we go about such developmental choices and what role should school science education play in developing abilities in our children to equip them to make choices in their adult life? It is therefore important that the curriculum tackles topics about sustainable development (if at all possible), about the finiteness of our resources, and about the nature of the developmental choices that lie in the years to come.

The science curriculum must integrate with the daily activities of individuals. It must pay greater attention to health, hygiene, medicine and medical practices, statistics and probability. One must find opportunity to teach about common medical conditions, emergency measures, implications of medical tests and their reliability. Generally speaking, the curriculum must prepare children to face medical conditions when they are older and are not necessarily in the best of health.

The curriculum must also promote a critical and scientific appraisal of indigeneous and empirical forms of knowledge. And encourage experiments and investigations of local practices on diet and health, traditional medicines, traditional water management systems

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and even yoga. This is not just to make them aware of their cultural heritage but more importantly, to make them realize that such practices are often grounded in good, albeit unarticulated, scientific reasons.

Today, teaching of physics in our country is slowly becoming a theoretical activity. Teachers, by and large, treat physics only as a body of knowledge that has to be transmitted to their students. This practice is strengthened by the nature of the examination system that tests only the ability to recall. The examinations do not require the exercise of analytical abilities. Since most teachers teach only what is expected in the examination, the impact of the examination system on physics teaching is catastrophic. The way out is to reform not only the curriculum but also the examination system.

With this situation, I would like to propose that the teaching of physics, particularly in the early years, be wholly based on experiments and investigations that students themselves perform. Once the basic principles have been taught, the applications should be in the form of investigations of some real-life problems that children are involved in, and which have to be conducted with the help of their teachers. Obviously this requires suitable equipment and teacher training.

Another feature of Indian schools is the intellectual isolation of school teachers. They have very limited educational resources available to supply them. A possible answer is to provide them access to the World Wide Web. (I say possible because of the cost of buying and maintaining computers.) The question to ask here is "Is it really necessary that schools keep up with the latest developments in hardware technology?" Shouldn't we seriously think of shifting the emphasis from producing more powerful computers at a given cost to producing cheaper computers of a given performance, at least as far as the school sector is concerned? Will the 10$ computer always remain only a dream? Since commercial organizations may not be interested, isn't this an opportunity for governments to look into?

Teachers must be provided space for personalizing the curriculum and must be supported.

Scientific and Technological Literacy for All: A Teaching Approach for Physics Education

by Janchai Yingprayoon
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Today science and technology invade all our lives. The quality of life is highly dependent on the technology we use and hence the scientific developments to which they relate. In the future, science and technology can be predicted to invade our lives to an even greater extent. It is assumed that physics is one of the core science subjects and is important for the advancement of scientific development. But it is not seen as interesting and relevant by the majority of students, failing to promote public awareness and understanding.

STL stands for Scientific and Technological Literacy for All. It is much more than the gaining of a body of knowledge and a way of knowing. It is more than being aware of applications of Physics, or developing a positive attitude towards science. In fact it is about gaining a meaningful education through a context of science. It definitely encompasses good teaching practices and hence, the professional development of teachers is seen as an essential component in its implementation.

STL can be put forward to mean developing the ability to creatively utilize sound science knowledge (and ways of working) in everyday life to solve problems, make decisions and hence improve the quality of life. This is based on acquiring educational skills at the intellectual, attitudinal, communicative, societal and interdisciplinary levels. Science, especially Physics, is taught in schools, because it is seen as an important part of general education.

It is important that STL should not be viewed as a constant target. It differs, depending on education received and the educational objectives stipulated at a given educational level within a specific country. This is a crucial point to note in guiding students to strive towards an appropriate level of STL. In fact, it is important to realize that students do achieve some degree of STL. But in putting forward STL as the teaching goal, it is STL which is enabling students to acquire educational objectives, to the degree intended by society, that is important. And the level of STL that the society expects can be more demanding as the students advance in academics.

The STL philosophy is based on science education as part of education; science education is approached from a societal perspective; and science education is based on constructivist principles.

The STL approach is very different from the uncontextualized emphasis on scientific principles and concepts used in most textbooks. It calls for maximizing the student involvement and the important transformation from teacher-

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centered approaches. But as the science and technology in use within society are often very complicated and demanding in conceptual understanding, the STL approach needs to find ways to meet this challenge. The learning process of STL require students to think, but the depth of thinking reflects the need to know. The STL teaching approach is based on the following criteria: Intended objectives covers the four educational areas; promotes science conceptual learning; involves student tasks that are related to the objectives; and distinguishes between problem-solving and decision-making; (student participatory; based on a consequence map created by the teacher; and assessment is directly related to the degree of achievement of the objectives specified for teaching).

In developing supplementary teaching material, the title of the material is important. The relevance is suggested by the title which should be societally oriented and must specify a concern or issue that is being addressed. Unfamiliar or abstract physics or science concepts are not part of the title. To create STL supplementary teaching material, it is suggested that the teacher starts from an issue or concern arising from the students' societal perspectives. This could arise from a student's question (often a situation at the primary school level) to a topical concern being expressed in the media (the newspaper, television, and radio). The approach can then be illustrated further by developing the following: General introduction (for both students and teachers); students' script (giving a scenario plus tasks to be undertaken); teachers' guide (assisting the teacher by suggesting teaching/strategies; how the script tackles about achieving the objectives and assessment of student ideas); some scripts need further background information to assist the teachers.

Physics Teacher Education*

by Helmut Kühnelt

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Students and teachers perceived physics as a difficult subject. When given a choice, students in upper secondary education prefer not to take physics. This results to low enrolment in university physics courses and shortage of qualified physics teachers.

Pre-service Education

Despite the different socio-economic backgrounds the problems in preservice education highlighted in the contributions of Matilde Vincentini, Italy, and of Vivien Talisayon, Philippines, have a lot in common. However, the models of teacher education are apparently different.

In Italy, high school teacher education is in a process of reform. Prospective teachers have to follow the full academic course in physics, to which a two-year study of education and teaching methods is added. Further reforms will follow from the transition of the traditional Italian University system to the "European system" with a bachelor degree after three years of study. Two main problematic areas have been identified by M. Vincentini: the quality of subject knowledge of the students and the underdeveloped cooperation between and among the university teachers of different fields of specialization and with teachers acting as mentors during the practicals in school. Subject knowledge after several years of physics specialist studies is described as incoherent between the different subdisciplines of physics.

The author takes the liberty to contribute similar observations with Austrian students. Austrian teacher students have to study from the beginning, two subjects as well as pedagogy and subject-related teaching methodology. (They can obtain a full physics master degree after passing additional courses). Their subject knowledge appears equally incoherent. Understanding of basic physics concepts is marginal even if some capabilities for solving typical problems and experimentation skills have been acquired. Students have not learned to transform the subject matter from the academic lecture to classroom language. To address these problems of transfer, a special course, in parallel to the introductory physics course, has been introduced recently.

M. Vincentini and the audience criticized the belief held too often at universities that good subject knowledge is sufficient for good teaching. The effect is two-fold: Lecturers are just delivering lectures without interacting with students, teacher students do not develop communication skills and, after returning to school, they tend to fall back on lecturing despite all instruction to the contrary during the short phase of methodical training. University teachers are necessarily preoccupied with their research (which is the main determinant for promotion) and are to a large extent, ignorant about recent developments in education.

V. Talisayon described some problems of science teacher education in the Philippines. The suggested solutions include the attainment of a center for teacher education, the National Institute of Science and Mathematics Education Development, which is well equipped both in terms of staff and of laboratories and equipment. Summer courses give teacher students of less equipped institutions the opportunity to practice hands-on learning and to conduct experiments in the laboratory. Aside from giving some insights on approaches to fostering metacognitive reflection.

* Synthesis of Round Table presentations at the GIREP-ICPE International Physics Education Conference in Barcelona, Spain in August 2000.

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Dick Gunstone reminded the audience the necessity of communication skills and training. He gave two examples: letting students write and edit an issue of a science teachers' journal, and having students teach each other in small groups. This is an argument for reducing the number of lecture hours—which are often considered to be too few by university teachers—and for giving more attention to projects and seminars.

This leads back to the question of depth vs. breadth of subject knowledge of teachers. The author considers communicating physics as the main task of a teacher. Communication requires understanding at a higher conceptual level that can be achieved in courses with very broad coverage of the subject.

Efficient communication requires also an understanding of the common blocks in learning. Despite the wealth of related research, quite often, initial teacher training does not expose students and teachers to this skill but is concerned mostly with subject content and specific teaching method. One has to ask also the question of how students are prepared for lifelong (autonomous) learning. Does the university tell the students that physics is a growing field of knowledge and that recent achievements of physics are rapidly becoming part of everyday commodities? Is the message passed to the students that studying at university is a short, but concentrated episode in the whole course of lifelong learning? How can the comprehensive stock of knowledge (as it is presented in lectures, laboratories and seminars) be sustained? In short, it has to be acknowledged by students as well as by professors that preservice education is insufficient.

Teacher Induction

Teaching practicals during pre-service education and gaining experience during the first few years in service are reported as major steps in the individual teacher's development. Despite its importance it has not been addressed strongly in the discussion. Usually, teachers and students and young teachers work under the guidance of mentor teachers. Mentors are acting on behalf of university or inservice training institutions. Again the question arises whether it is sufficient for a mentor to have a record of excellence in teaching or if some special training—with continuous updating—should be required. In-service training is required for the mentors. In addition, a support system has to be established. This allows exchange of experiences between mentors, teacher educators and even trainees. Postgraduate students are given the opportunity to be exposed to physics education research. They could also contribute to physics education research through their work with pupils and teachers. Also, this will strengthen ties between teacher mentors and university, which will raise quality standards of teacher education.

In-Service Education

Lifelong learning is recognized as a necessity in a changing world. The rise of information technology and its implementation in schools provide an example of how a large body of teachers has to update their knowledge in a field, which was virtually not existent, when the majority of active teachers received their initial education.

At this conference, a number of contributions highlighted problems inherent in inservice training. Difficulties with transmitting innovative teaching approaches to active teachers have been reported. An interesting approach to train teacher trainers has been presented by U. Ganiel and the Weizmann Institute group. According to the constructivists' point of view, learning in-service courses have changed, and participants responsibility have increased for their learning, both with respect to contents and to methods.

Seta Oblak described how teachers at school and university cooperate in Slovenia. This has led to postgraduate courses for a master degree in science education. It has also led to successful joint projects of curriculum innovations. She also pointed out that only a minority of teachers takes part in those activities and that the majority is waiting for proposals and materials for quick and easy use in the classrooms. In this situation, networking is a necessity to reach the less active, but responsive teachers. Networking may be supported by e-mail and electronic discussion, by journals and by regular meetings. Networking is a precondition for raising professionalism among teachers. EUPEN conducted a survey in several European countries about the needs of physics teachers in preservice as well as inservice education. This has been a topic during Round Table 2. Sylvia Pugliese Iona, a co-investigator of EUPEN survey, reported during Round Table 3 about additional findings of this survey. She stressed the importance of professional contacts and networking. And raised better working conditions for teachers. We interpret this not only as a request for adequate provision of laboratory equipment and teaching hours, but also for increased mutual support through collegial exchange of experiences and new ideas—as well as reflection on the aims of physics education in the different areas and age brackets. Professional associations like ASE in UK or AIF in Italy play an important role in this respect.

Concluding Remarks

To use an analogy from the performing arts, the more difficult it is to play a piece of music, the more work is required not only for exercise but also for reflection—both components working together for an interesting, even fascinating performance. In a similar way, a truly professional teacher does not only have solid subject knowledge, a rich repertoire of teaching methods, etc. but also have reflective activities.

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Therefore, one of the tasks of inservice training is the professional development of the reflective abilities of teachers. (Of course, this extends also to preservice education.) Experience from a number of in-service courses with this aim—shows that three conditions have to be met: opportunity, time and support. By opportunity we do not mean the fact that such courses are offered, but we consider the diversity and quality of learning experiences in a peer group which is a very important criterion. Development needs time. One example is in the two-year course in pedagogy and methodology for science teachers in Austria (PFL), teachers document and investigate an aspect of their classroom work. Repeated analyses of their findings lead them finally to an understanding and enable them to draw conclusions from their case study. Support is a crucial condition. It can be provided in several ways. The first is mentoring, the second—and at least as import—is mutual support of the participants of the course. In the PFL case, small groups of about eight participants and one team member meet regularly during the two years to discuss the progress of work and to assist each other by attending lessons, interviewing pupils, and giving feedback to the hosting teacher. The group is stable and facilitates the development of mutual trust and confidence.

Many important aspects of in-service training could not be addressed during the two-hour round table. One, which should get more attention and support, concerns internships of teachers in research groups and in industry. Teachers have to orient their pupils about science research and the workplace—brochures cannot replace direct experience.

Discovery - Interactive Approach to Introductory Laboratories

by P. Maurone, F. Maloney, M. Hones, D. Shaw, and L. DeWarf

Over the past several years we have introduced the discovery – interactive approach into all our introductory physics laboratories. This is in contrast to the “demonstration-verification” approach previously used. In the old approach, the whole lab period was taken up with the drudgery of taking data and gave little opportunity for the student to “just try things” while in the laboratory, so most of the analysis was done off site. This, of course, is not the way most experimental research is conducted. To give the students a more realistic sense of the scientific method in action, they must participate in all phases of the experiment while in the laboratory. Rapid data analysis is required to achieve this. For this purpose, we use a PC-compatible computer and PASCO’s interface with the Data Studio software for analysis. Using this combination, or one similar, students can collect data, analyze it immediately, and then proceed with “what if” scenarios and still have time to prepare the report while in the laboratory. We report here our experiece with a nonscience major’s course. The course philosophy is given, as well as descriptions of several experiments.

At Villanova we have developed a course for nonscience majors called Planet Earth. It is a joint effort by the Department of Physics and the Department of Astronomy and Astrophysics. It is a team taught by members of both departments. The idea is to get students involved in the joy of discovery and analysis by presenting interesting systems and events and eventually peeling back the layers to understand the underlying principles. This is in contrast to most textbooks where the fundamental principles of the discipline are presented first and then the applications. We try to confront the phenomena first, and then develop the fundamental principles. For example, we consider mass extinctions, thought to be caused by comet impacts, in order to introduce the concepts of motion, energy and heat.

Additional phenomena used to spark interest in the search for underlying principles come from earthquakes and volcanoes as well as examples taken from sports, weather, fossil dating, auto-racing cosmology, and stellar evolution.

We generally discuss these phenomena as occurring on the surface of the earth or is observed from the surface. This brings out another general distinction in the presentation of course material. The two ways of knowing - observation and experimentation. The laboratory is divided into an equal number of observational and experimental laboratories. The observational laboratory deal with simulations of events as observed from surface of the earth astronomical events. The experimental laboratory look at parts of a composite system in a controlled way, a luxury not available to the astronomer, who must deal with the distant objects as composite, using only the light arriving at the surface of the earth with which to experiment.

The complimentary nature of these two ways of knowing is shown in the experiments on light. In the lecture, this is first achieved with a description of Galileo’s and Newton’s work, where the observations in the heavens and experiments on the surface are related.

The rest of this paper will deal with the experimental laboratory, the observational laboratory, having been presented elsewhere.

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Results of the EUPEN Regional Fora - 2000

by H. Ferdinande and E. Valcke

The Student Experience

EUPEN and its working groups initiated a series of inquiries on physics studies in universities different countries.

The objective was to obtain information on similarities and differences of physics studies between the different countries in Europe and different universities within countries. The parameters include content, level, teaching/learning styles and student workload. The survey was carried out by means of questionnaires sent to institutions and students. The data used in this presentation were collected in 1997 and 1998. The results on first-degree student workload, teaching/learning styles and doctoral studies are summarized in this article.

Student Workload

Some difficulties identified when making comparisons between countries/ institutions are:

1. The structure of studies differs from country to country.
2. There are large variations in actual length versus legal length of study. Overrun factor is equal to the actual length over the legal length.
3. The private study part as estimated by the institutions can be questionable. The figures as given by the students might also be questionable.
4. Students are different. The data should preferably relate to an average or typical student, which is probably a nonexisting entity.

The differences are already apparent in the way admission process to physics studies at universities is handled. Some countries require a final examination to secondary school high school, baccalaureate, gymnasium (usually obtained after 12 years at school). There is a clear correlation between the entrance fraction and the overrun and success rate, in the sense that there is less overrun and a higher success rate for tougher entrance requirements.

Data have been obtained on the workload divided into contact hours, which again were divided into lectures, tutorials (problem solving), laboratory (experimental work) and computing, and noncontact hours, representing homework, private study, writing reports, etc. Further, the private study time (homework) has been estimated both by the institution and by the students. About one third of the cases studied results to a good match. One third of the institutions overestimates and one third underestimates the private study time.

Teaching/Learning Styles

The study time varies considerably as well as the actual length versus the legal length and the success rate. It appears that each institution has developed its own route to physics education. In most countries, the institutions decide on what to include in the curriculum content. Various patterns can be obtained. One such trend is obtained by plotting the total number of contact hours for basic mathematics and general physics (including classwork and laboratory) against the number of hours for classwork and laboratory. The examined institutions then fall in four fairly well-separated groups covering the four possible cases: 1) large number of contact hours, large number of classwork/ laboratory hours; 2) large number of contact hours, small number of classwork/laboratory; 3) small number of contact hours, large number of classwork/laboratory hours; 4) small number of contact hours, small number of classwork/laboratory hours. Another trend is the way the progress of the student is controlled. There are three patterns: (1) the student who is in complete control; (2) the institution is in complete control; and, (3) the student can decide when to take the exams but with the institution still being in control. There is a correlation between these patterns and the overrun and success rate.

Qualitative factors were investigated: Formative versus factual teaching/ learning style and it is of course a matter of individual perception. There is a clear bias towards formative, with a number of institutions perceiving their courses well-balanced. The mathematical level is another factor. To a certain extent this can be quantified as the number of contact hours for basic mathematics, also available from the questionnaires. From these the ratio between contact hours for basic mathematics and contact hours for general physics ranges from nearly 2 to around 0.5. There are large differences in the way it is done in the same institution for year one and later years. Differences in the way of doing laboratory work are also apparent, ranging from students being fairly passive in the sense that the exercises are of the cookbook type, to the very active student where the students start by formulating a project. The passive behaviour is by far the most usual. Examinations are conducted quite differently in the different institutions, both in the form of - written or oral and in content - multiple choice, discussion and general concepts, thorough and analytical treatment or problem solving. Most institutions use both oral and written

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examinations, but in seven institutions 90% of exams are written, two institutions have only oral examinations and five have a fifty/fifty distribution. Most institutions use problem solving and thorough treatment in the written and oral part, respectively. The fact that examinations differ considerably is also witnessed by the responses to questionnaires sent to some exchange students. They find the form of examination at the host institution quite different from the one at home, not necessarily more difficult but just different. In general, however, the students going to the UK, find the examination easier, because it does not require memorizing work.

Conclusion

The first-degree student experience shows that the European Physics departments offer a great variety of study patterns. No easy recognition procedure from one country to another is available. Two-tier study organization is so far limited but some countries are at present committed to implement a reform of their study organization.

The doctoral degree is widely recognized as clear evidence for the ability to carry out independent research. In actual practice and circumstances, there appear to be a rich variation among the various countries of Europe.

We always felt that such a richness in educational traditions must be preserved. Nevertheless we fed that enhanced reciprocal knowledge and sound comparisons can make each national approach richer and more fruitful, favouring a better readability of the overall European education in physics and improving the mobility of students and graduates within Europe.

Organization of Physics Studies

The organization of physics studies at both undergraduate and doctoral level was studied, by means of questionnaires, which were sent to the members of the network. The preparation and analysis of these questionnaires were done in collaboration with other investigators. Results from the first thee years and the discussions at the EUPEN Fora were re-evaluated in the fourth year and the results were presented in different forms.

Undergraduate Studies

The undergraduate questionnaire was distributed to all EUPEN members in 1997 and 76 replies were received from 22 countries.

The main conclusions were as follows: The length of the undergraduate degree has a range of 4 to 7 years, with an average of about 5 years; the entry age to university varies from 18 to 20, so that the degree can be completed at age 22 to 27 in different countries; usually instruction is in the local language or in several countries' languages, but some courses are also available in English or other major languages. Courses in English are frequently available in Scandinavia and the Netherland; female participation is low (10-20%) in Scandinavia and Northern Europe. The participation figures for Southern and Central Europe are better (30-50%). However, in some cases, the female percentage is boosted by inclusion of physics teaching degrees; the average dropout rate is about 30 percent, but this conceals very large variations. Due to the differences in university systems, intercomparisons are extremely difficult. It is not clear where the students go; some may well take up other courses; student funding and fee regimes vary drastically between countries. This provides a barrier to students studying in another country. This is even true within the EU, where all EU-students should be treated on the same basis as home students; and on average, the cost of educating a student is about 30 percent of the GDP per capita in the country. On the same basis, the cost of living for students at home is 18% and away from home, 30 percent.

Doctoral Studies

The doctoral studies questionnaire was distributed to all EUPEN members in 1999 and 93 replies were received from 24 countries.

This may include time spent on an intermediate qualification such as the French DEA or the British M.Sc.; students typically achieve a doctorate degree at age 28, with a range of 25 to 31; there is widespread support for the development of a European doctorate degree and general agreement on the criteria required; the existence of an examination system for entry to doctoral studies, in a few countries, is a barrier to foreign students undertaking studies there; the lack of a coherent system for financial support is probably a more general problem. In many countries, doctoral students are partially supported from a variety of sources and much effort is extended to gather adequate funds; several countries charge substantial fees for doctoral studies, which presents difficulties for doctoral student mobility between European countries. This will have the same effect as the fee policy in the UK has had on undergraduate student mobility there.

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Curricula Structure and Development

Conclusions on the Curriculum Structure

The physics studies in 21 European countries show a great diversity; fundamental physics studies are dominant in the curricula; laboratory teaching hours increase from the 1st to the 4th year; and there is no indication of a possible level of qualification directly related to and physics in the third year although in the UK and Ireland this can happen.

Use of Information and Communication Technology

The new learning conditions imposed by the advent of ICT were investigated: What changes will come about in the classroom environment, in timetables, in boundaries between subjects, in the role of teachers and textbooks, in lifelong training....?

The questionnaire on "e-education" was divided into five main sections covering the following topics: computers in physics course, information retrieval, communication skills, student responsibility for course choices, and participation in departmental organization.

As usual with this type of questionnaire, which is being sent to many different countries, there is an inevitable danger of ambiguities/misinterpretations although this does not appear to be a major problem in this particular case.

An Overview of the Returned Questionnaire Forms

Ninety universities responded to the questionnaire. It was immediately apparent that there were much larger variations than had been present in the earlier questionnaire on course structure. Also a considerable variation in the answers received from one coutnry was apparent. Finally the "skills" development in different institutions is probably the result of individual initiatives.

Student Access to University IT Facilities

Seventy-seven of the ninety institution indicated that they had computer terminals available for normal student use in the physics building, with an average of forty-six terminals or computers available.

To approach the previous estimation in a semi-quantitative way, we computed the ratio of the number of consoles divided by the number of students using them. This was done for each year of study and in each university.

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Research in Physics Teaching

Several issues, including the decline of recruitment and the reform of the studies going on in several countries, require a strong rethinking of the way in which physics is taught. To this aim the Group on Research in Physics Teaching has analyzed the information collected from two different communities. The first one is that of the physicists involved in disciplinary research and teaching in university physics courses. The second one is that of the physicists involved in research in physics education and training prospective teachers. In most European countries, the two communities live in separate departments (Physics/Science Education). The information concerned: a) the state of the art of physics teaching in the physics departments; b) the influence of educational research on physics teaching; and, c) the level of communication between the two communities.

Summary of Results

Our basic findings and conclusions are the following: (a) In several countries the organization of the studies is structured in two cycles (Bachelor - Master/PhD). Many examples of bachelor courses open to various professions are available, but it seems difficult to shift the master's degree from the traditional training of scientists to that of "science trained high-level professionals." This involves a rethinking of the basic contents in terms of the quantity and quality needed for the use in different professions, with due consideration to the requirements of the society. (b) The results of educational research draw the attention to some necessary changes in the teaching methodology. Most university teachers, however, are not acquainted with those results and do not think that educational expertise is needed for their teaching activity. It follows that now the methodology is mainly of the recitation type and often rather inefficient. Some examples of change towards an interactive methodology are available in the departments involved in the training of teachers. The promotion of the educational expertise of university professors needs particular attention. (c) Overall, the two communities agree that there is lack of communication between them. Both feel this lack as a drawback for improving university teaching. We feel that the main obstacles to overcome are: The belief of most scientists in the validity of the traditional way of teaching and

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the lack of motivation for change by the scientists who feel that the disciplinary knowledge of the researchers in education is not up-to-date.

It therefore seems necessary for both communities, while working to establish a better communication on educational issues, to focus on the definition of the quality of the basic knowledge in physics needed for the scientific literacy of the high-level professionals. This is particularly important today when changes in the university organization would be desirable in the light of the ambition to make the European systems converge, as summarized by Dr. Guy Haug in his comments on the Bologna declaration.

The universities and their physics departments should also organize sessions for the training of university teachers. Up to now, in many countries, the evaluation of the work and the promotion of university professors is based mainly on his/her research activity. A change is needed in order to give more weight to the quality of the didactical experience.

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The handouts were e-mailed and posted on the Web at least a week before the scheduled internet chat (with limited voice interaction) session. The course availed of the free chat room in the math.net website. For the voice chat, the Roger Wilco software was used. Pictures of the facilitators and some participants were posted on the web.

The chat was a first-time experience for all participants who indicated that they enjoyed the interaction with the facilitators and student participants from other countries. At any one time, two or three facilitators were interacting with the participants. The questions were not limited to the topic on hand but often dealt with differences in the physics curriculum of the participating countries, including physics teaching conditions and strategies.

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The experimental laboratory cover kinematics, dynamics, heat, light and radioactivity. The discovery approach is used for most of them. A general description of the phenomena is given and the measurable variables identified. It is up to the student to measure them and find a relationship between them, using the software provided.

After a few weeks in laboratory it becomes apparent to the student that there is an underlying unity in seemingly very diverse phenomena. For example, a decreasing exponential is fitted to temperature and time data from a cooling object. A decreasing exponential is also used to fit data from radioactive radon gas decay, light alternated through varying depths of colored liquids as well as gamma particles alternated through various thicknesses of absorbing material. The inverse quadratic nature of enumerations from point sources is discovered for light and radioactivity.

We present results from several of the experiments performed throughout the year that we feel bring out the themes we have stated: discovery/interaction, observation/experimentation and the underlying unity of nature.

First GIREP Seminar on Development of Formal Thinking in Physics

by Ian Lawrence and Marisa Michelini

GIREP will conduct its first seminar on Development of Formal Thinking in Physics on September 1 to 15, 2001 in Udine, Italy. The seminar is organized by Ian Lawrence and Marisa Michalini.

Developing formal thinking in physics means acquiring a network of connections, assigning meaning to imagined elements, and allowing navigation around the landscape of physics.

The themes of the seminar are: a) Interplay of theory and experiment. Idealization issues in embedding and linking practical experiences with developing structures; b) Modelng and work. Issues in developing imaged worlds and connecting them to the phenomenal world; and c) Mathematics: Exploring the special case of developing physics through the descriptive language of mathematics.

Science Teachers as Researchers

Some of us are involved in research about teachers and students. To those who are interested in doing studies on teaching and learning may communicate to Brian Woolnough, Oxford University Department of Educational Studies, Oxford, U.K.

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Working Year 4

During this dissemination year of EUPEN, our group has not had any further contacts with the respondents of the enquiries during the first three years. It has been a year of reflection and dissemination of the results previously obtained. Some ofthe members of the group have had the possibility of giving seminars and lectures in the home departments or elsewhere. In all three regional fora WG5 has presented the results obtained in the previous years, and the interventions have evoked stimulating dialogues with the respective audiences.

A special occasion for interesting discussions in the context of our results was the GIREP/ICPE conference in Barcelona in September 2000. This meeting was devoted to "Physics teacher education beyond 2000". Naturally it was attended by a large number of researchers in the field, and the participants came from many countries also outside Europe. It also brought those people active in EUPEN together with representatives from other organisations working on the field of Physics Education, as for example the EPS Division on Education, GIREP and the IUPAP Commission on Education (ICPE).

One issue which was raised during this conference, in a round-table discussion on "Contributions of Institutions to the improvement of physics teaching", was the one concerning the gap between "the two communities": the academic physics researchers/teachers and the physics education researchers. These two groups of researchers naturally ought to be in close contact with each other. Contrary to this, they are often not even working in the same departments and there is sometimes a lack of trust between them. The reason for this could be a feeling that the other group does not really appreciate and/or master the issues and methods used in the other group.

The answers obtained by our working group have clearly confirmed this observation and stress the urgency to see to it that this gap is eliminated. One indication that a development has already got started is the fact that in many institutions the teaching experience is now considered to be as important for career positions as research experience. Some countries, like Sweden, even have a third criterion to be judged in applications to higher posts, namely contacts with "the outer world", with the public and with the media. Another example, also from Sweden, shows that things are developing. At Uppsala University a chair in physics didactics has been established this year for the first time, and the holder is now placed in the Physics department.

It is also known that some universities require newly appointed lecturers and professors to take pedagogical courses. It is no longer considered evident that good teaching is an automatic consequence of outstanding research experience! The results of WG5 have already been disseminated, not only this year, but all the years that the EUPEN books appeared. To give one example, the inquiries supported ongoing innovations in the Netherlands. It has become clear that in order to attract physics students in the future, one needs good teachers and in order to get good teachers, one needs good teaching at the university. So in the Netherlands there is a growing awareness that universities have to emphasise much more strongly the importance of education and teaching in the physics departments. This resulted in the fact that every department now has a Head of education who is responsible for everything that is connected with the teaching of physics at the university. It is clear that EUPEN activities have played a role in increasing the appreciation of the importance of good teaching.

The situation in central and east European (C/EE) countries (especially the Czech Republic, Slovakia, Poland and Hungary) was that the education of school teachers was also provided at so-called High Pedagogical Institutes. Since 1990 these activities have been gradually transferred to universities. All of the students are educated in two subjects (major and minor area of study). Physics students study physics-mathematics, physics-chemistry, physics-computer science, etc. These universities are not participants of EUPEN and therefore the experience gained by these institutions regarding the education of physics teachers is missing. In these universities research in education (or didactics) is conducted as a general field of study, and also specifically in Physics education. There is also the possibility to perform doctoral studies in Physics education (Physics didactics). There are many professors, associate professors, and assistant professors (lecturers) of Physics education.

To introduce new models in Physics education, for example computer based teaching, and to obtain support for research in this field, many universities participated in one or more projects of the TEMPUS programme, e.g., University of Poznan (PL), Comenius University (SK), Matej Bell University (SK). Due to the increased activity in this area by C/EE countries, different results may be expected in the data for these countries in comparison with west European countries. Physics courses have gone through some changes with the introduction of ECTS, the European Credit Transfer System. The next changes would be effected if the Bologna declaration is implemented to develop new curricula for the two-level university degree system.

Finally, a most important and concrete outcome of the previous activity of WG5 has been the influence of the above results and findings on the Physics studies reform going on at present in some European countries, more specifically in Italy. Here the development of the new curricula for the two-level university degree system (3+2), as well as the changes in the didactical methodology, have been guided by serious consideration of most of our suggestions and recommendations. The EUPEN activity therefore resulted in a concrete service for the advancement of physics teaching in Europe.

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