International Newsletter on Physics Education

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ICPE Chair's Corner

It is time to celebrate: we just turned fifty! The *International Commission on Physics Education* (ICPE) was conceptualized at the first ever international conference on physics education held at UNESO House, Paris from 28 July to 4 August 1960. It was established soon after on 9 September 1960 at the X General Assembly of the *International Union for Pure and Applied Physics* (IUPAP) held in Ottawa, Canada, as its 14th Commission. Although IUPAP came into being in 1922 – with a mission to assist in the worldwide development of physics, to foster international cooperation in physics, and to help in the application of physics toward solving problems of concern to humanity – it took 38 years for realization to dawn that Physics Education is central to this mission.

It is a remarkable coincidence that this year ICPE joined GIREP and MPTL in sponsoring and organizing its annual international conference titled *Teaching and Learning Physics Today: Challenges? Benefits?* at the historic city of Reims – mere 45 minutes train ride from Paris – renowned also as the Champagne capital of the world! Needless to add, on the sidelines of serious deliberations, we explored the UNESCO world heritage sites; enjoyed the gourmet food; visited the maze of cellars in the city; enjoyed miles of lush green vineyards and hospitable introduction to the art and science of the bubbly wines refined by *tasting* in true scientific tradition.

The French hosts graciously dedicated the last session of the conference on 27 August to celebrating the 50th anniversary of ICPE, springing ceremoniously a surprise cake. As Chair, I had the privilege of delivering a plenary talk on the commission, focusing on its history, activities, and most importantly, the challenges and opportunities ahead of us. In an accompanying article in this issue, I reconstruct the story of genesis of ICPE, using the few historical narratives available today. Herein, I also emphasize the common denominator of global concerns on physics education that mandate international linkages, creation of advocacy and action networks, and collaborative projects for promulgation of best practices tuned to regional and local needs.

A concrete step forward in global cooperation is the realization of a *World Conference on Physics Education.* First mooted at the commissions meeting at Cyprus in 2008, this entailed perseverant discussions with key international organizations. Dean Zollman (General Secretary ICPE) and Ton Ellermeijer (President, GIREP) took the lead. We are happy to announce that the first ever World Conference will indeed be organized in Istanbul, Turkey, in July 2012 on the theme *The Roles of Context, Culture and Representations in Physics Teaching & Learning*. Envisaged as a series of conferences with a four year periodicity, we hope the initiative will bring on board all stakeholders and key international organizations.

The effervescence of champagne at Reims still with us, we now look forward to raising many a toast in the coming decades as we set new milestones for ourselves and create an ever increasing circle of collaborators and international friends to achieve our goals.

Pratibha Jolly, ICPE Chair

In this issue

ComPADRE: Online services for Physics and Astronomy Education

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This article is a slightly shortened version of a more complete paper, which may be read on the web site:
http://web.phys.ksu.edu/icpe/newsletters/n60_supplement.pdf

Imagine a situation where someone needs help finding and using physics teaching and learning resources. This might be a new high school teacher with a limited physics background who has been assigned to teach a conceptual physics course. It could be a physics professor who is teaching statistical mechanics for a third year and desires to give her students experience with computational modeling of complex systems. Perhaps this is a student wishing to gain more experience with physics research or a parent wishing to enrich the education of a gifted son or daughter. Because we live in the era of internet information, it is very likely that help will be sought on Google, Wikipedia, or even Youtube. Although all these web services are excellent for what they do, it is unlikely they will result in the best pedagogical outcome. In this article I describe a web service with a physics education focus, ComPADRE, (http://www.compadre.org), an education "library" in the sense of organizing and managing many sources of information on physics and astronomy learning and serving its patrons by helping them find and use these resources.

The ComPADRE project has four main goals:

- to support the broad spectrum of physics and astronomy education, K-12, undergraduate and graduate, and informal education, through the organization of learning resources;
- to partner with researchers and curriculum developers to disseminate best practices for science education;
- to provide a range of web services to physics and astronomy instructors and students for learning and professional development; and
- to integrate our services with the education efforts of professional societies and other education support organizations.

With NSF funding, ComPADRE went online in 2003 as a network of educational resource collections. Each of these individual collections was targeted to a specific audience, such as high school teachers or students in quantum mechanics. For each collection, an editor and the ComPADRE staff designed the site and selected resources for the collection's audience under the supervision of a ComPADRE professional society partner (AAPT, AIP, APS, and AAS). By 2006, when it became a pathway of the NSDL (http://nsdl.org), ComPADRE had more than 3,000 resources in the library and more than 26,000 visitors per month. Currently there are nearly 11,000 resources in ComPADRE and the collections receive up to 110,000 visits per month. In addition, more than 900,000 visitors per month use a separate curriculum resource hosted by ComPADRE, The Physics Classroom.

Why and How of ComPADRE

A common question about the need for ComPADRE is: "I can find anything on Google, so why would I use anything else?" The answer contrasts depth and breadth. ComPADRE does not replace Google; Google does its job very well. Google does not, however, provide the only useful web tools.

Consider our new high school teacher looking to enhance a kinematics lesson with an interactive simulation for in-class display and student homework.

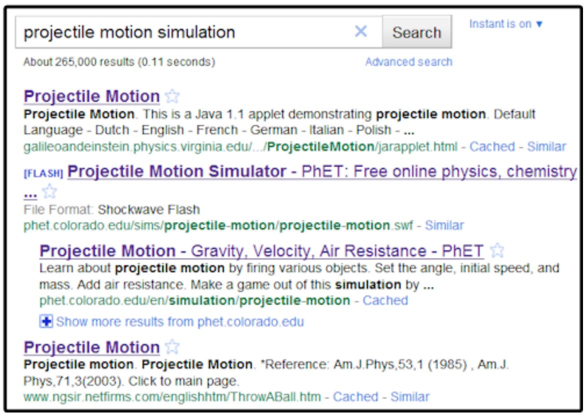


Fig.1 – Google search for: projectile motion simulation

Figure 1 shows the results of a search on Google, specifically for "projectile motion simulation" (without quotes). The result is approximately 265,000 links, some of them quite good and some of them not particularly useful for our teacher. There is no information on the quality of these links as learning materials or how they are best used in a class.

Pedagogical effectiveness of resources cannot be used as a priority in the teacher's search.

One benefit that ComPADRE adds to the search process comes from a focus on the audience's interest in physics and/or astronomy learning. Figure 2 gives an example of the detailed information provided about each learning resource listed in the ComPADRE catalog.

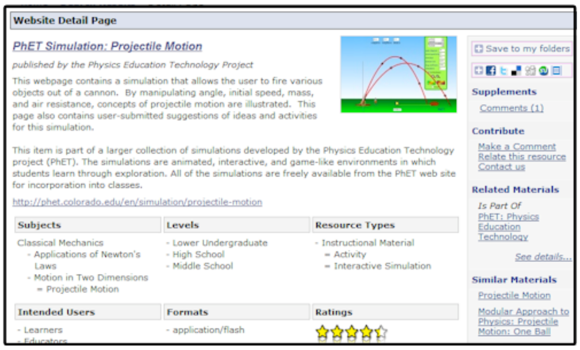


Fig.2 – Example: ComPADRE detail page

Besides the title, author and web address, there is a description written for the use of physics teachers and students, subject and grade level information, and information about the potential audience. There are also links to other resources that might be of interest to the user, either because of the similarity in topic or compatibility for learning activities. The selection of materials and addition of scientific and pedagogical information is the work of editors and librarians who understand the users' needs.

The simplest way to learn about ComPADRE is to give it a try. One might start with the oldest collection, the PSRC (http://www.compadre.org/psrc). On the homepage are the basic tools for finding materials, with the search box at the top and links available to browse the PSRC by physics subject, perform an advanced search, or connect to editor-featured materials. Entering a physics term in the search box will bring up a page with a list of relevant materials from the database. Each listing includes the title, part of the resource description, details available in a mouse-over, and a direct link to the resource URL. The title links to a detailed information page such as that shown in Figure 2. The tools at the top of the search results page can be used to refine the search to specific topics or types of materials.

Table 1 provides an overview of some of the ComPADRE collections, with a description of audience, goals, and resources. More information about all the current ComPADRE collections can be found at http://www.compadre.org/portal/Collections.cfm.

Table 1:Description and highlights of example ComPADRE collections

Physical Sciences Resource Center (All topics)	http://www.compadre.org/psrc/: The PSRC is the comprehensive collection of resources from all topics and levels of physics and astronomy. It is also used for cataloging and library development.
Physics Front (Pre-college Teachers)	http://www.compadre.org/precollege/: The Physics Front is designed for middle- and high-school physics with a focus on new and cross-over teachers. It includes dozens of editor-created topical units containing recommendations for teaching specific topics and courses.
The Nucleus (Physics Students)	http://www.compadre.org/student/: The Nucleus, managed by the SPS, engages physics majors in the discipline of physics. This collection hosts databases of student research opportunities, outreach activities, and scholarships, along with discussions, contests, and book reviews.
The Quantum Exchange (Quantum Physics Courses)	http://www.compadre.org/quantum/: The Quantum Exchange collects resources for quantum physics. Simulations and visualizations are stressed because of the non-intuitive nature of the topic.
Physics-to-Go (Informal Science Education)	http://www.compadre.org/informal/: Physics-to-Go is an online magazine of physics and astronomy concepts developed for the general public. All of the issues provide links to examples of and resources about the issue topic.
Physics Source (Intro Undergrad Physics)	http://www.compadre.org/introphys/: The Physics Source provides curriculum resources for introductory undergraduate physics courses from calculus-based to "poets". The editor highlights research-validated resources and best practices in science education.
Advanced Labs (Lab Courses)	http://www.compadre.org/advlabs/: The Advanced Labs collection includes lab manuals and teaching tips for the upper-undergraduate laboratory experience.
Physics Careers Resource (Career Information)	http://www.compadre.org/careers/: The Physics Careers Resource is a new web site with information about physics majors and their careers. Sections are written for students, parents, and educators.

The ComPADRE technical staff provides collection editors with the tools to select, organize, and highlight resources for their audience. However, it is not just the editors who can add value to the ComPADRE collections and the materials listed in the database. Any registered ComPADRE user can suggest resources to be added to a collection, if approved by the editor, or make a comment about or rate any existing item. Registration (free) allows the user to gather their favorite materials and organize them in any structure of folders and sub-folders that fits their needs. For example, a teacher can sort materials into course folders, organized by sub-topic. The teacher can also include links in these file folders to materials not on ComPADRE, such as personally-developed worksheets posted online. Finally, users can share sections of their personal collections with other ComPADRE users, watch other users' shared folders, or create folders that can be edited in collaboration with others.

Special Features and Collaborations

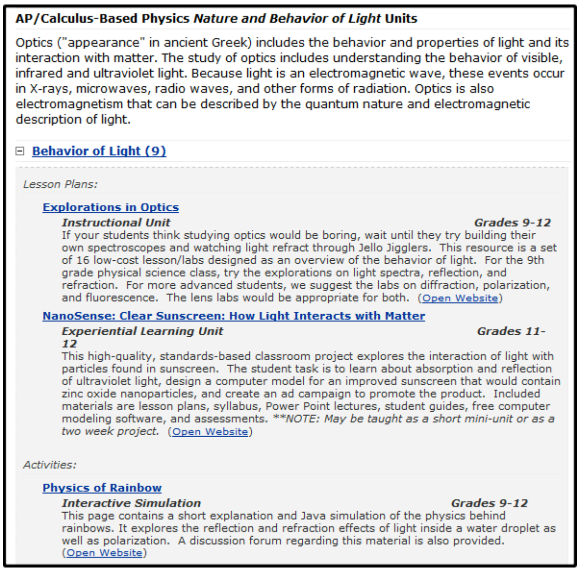
Although the ComPADRE database of links to, and information about, learning materials is the foundation of the library, the ComPADRE project does not stop there. There are many other efforts that expand its activities and impact. These are web-based services that build on the library infrastructure and user tools.

One important service is the resource repository that allows ComPADRE to host and archive materials. The ComPADRE content repository holds a wide range of materials, from textbooks disseminated by their authors on ComPADRE to large collections of interactive simulations or student activities to posters and papers from conferences and workshops.

Another ComPADRE service is the hosting of special databases. Several collection editors are using these databases to provide information of interest to their users. The first, and perhaps largest, example is a tool to connect students with summer research opportunities. Each year approximately 200 providers list hundreds of positions on the ComPADRE student collection. Thousands of students take advantage of the list, with more than 35,000 opportunities viewed per month. Similar databases are used for the Physics Careers collection (http://www.compadre.org/careers), to distribute information about physics student clubs, and to list Physics Education Research groups around the world. (http://www.compadre.org/per/programs/)

The semiannual Adopt-a-Physicist events are part of a unique program made possible by the ComPADRE database, personal profiles created by ComPADRE users, and the ComPADRE communications tools. (http://www.adoptaphysicist.org) In Adopt, physicists sign up to be selected by high school classes for two weeks of online discussion. This provides students around the world access to working scientists in a broad range of occupations. The students learn more about science and the activities of scientists. The physicists end up answering questions that range from "What was your most exciting discovery" to "Do you like macaroni and cheese". This program is highly praised by both the teachers and the scientists involved.

Another special ComPADRE feature is the Topics and Units interface on the K-12 collection (http://www.compadre.org/precollege/static/topics.cfm). As shown in Figure 3, the editors use this tool to make resource recommendations for teachers broken down by course type, general topic, specific topic, and type of resource. These units are aimed at new physics teachers to help jump-start their classes. The unit resources are sorted into lesson plans, student activities, references, content support, and assessments. Both the content and use of each of the selected resources is carefully presented in the unit description to provide help to the teacher. These recommendations, featured on the Physics Front home page, receive about 30% of the traffic on the K-12 collection.


AP/Calculus-Based Physics *Nature and Behavior of Light* Units

Optics ("appearance" in ancient Greek) includes the behavior and properties of light and its interaction with matter. The study of optics includes understanding the behavior of visible, infrared and ultraviolet light. Because light is an electromagnetic wave, these events occur in X-rays, microwaves, radio waves, and other forms of radiation. Optics is also electromagnetism that can be described by the quantum nature and electromagnetic description of light.

⊟ Behavior of Light (9)

Lesson Plans:

Explorations in Optics
Instructional Unit ***Grades 9-12***
If your students think studying optics would be boring, wait until they try building their own spectroscopes and watching light refract through Jello Jigglers. This resource is a set of 16 low-cost lesson/labs designed as an overview of the behavior of light. For the 9th grade physical science class, try the explorations on light spectra, reflection, and refraction. For more advanced students, we suggest the labs on diffraction, polarization, and fluorescence. The lens labs would be appropriate for both. (Open Website)

NanoSense: Clear Sunscreen: How Light Interacts with Matter
Experiential Learning Unit ***Grades 11-12***
This high-quality, standards-based classroom project explores the interaction of light with particles found in sunscreen. The student task is to learn about absorption and reflection of ultraviolet light, design a computer model for an improved sunscreen that would contain zinc oxide nanoparticles, and create an ad campaign to promote the product. Included materials are lesson plans, syllabus, Power Point lectures, student guides, free computer modeling software, and assessments. ***NOTE: May be taught as a short mini-unit or as a two week project.*** (Open Website)

Activities:

Physics of Rainbow
Interactive Simulation ***Grades 9-12***
This page contains a short explanation and Java simulation of the physics behind rainbows. It explores the reflection and refraction effects of light inside a water droplet as well as polarization. A discussion forum regarding this material is also provided. (Open Website)

Fig.3 – Typical unit on the nature of light.

There are also several special collaborations that have been very important for the growth and function of ComPADRE. These have resulted in important tools, dynamic collections, and quality resources for our audiences.

- Every search on ComPADRE can include results from our partners through a Federated Search, broadening the scope of the resources made available to our users. These additional resources from other content providers and libraries are shown on the "Partner Results" search results page. Our search partners include the NSDL, MERLOT, and the

Astrophysics Data System education database.

- The Physics Teachers Education Coalition (http://www.compadre.org/ptec), an effort of the APS and AAPT to improve the quality and quantity of physics teachers, uses ComPADRE as its web host. The PTEC staff uses the ComPADRE tools to build a library of resources for teacher education, provide information about the partner institutions of the Coalition, and host the proceedings of PTEC conferences and workshops.

- The Physics Education Research Community is a vital partner for ComPADRE. The PER Collection, PER-Central (http://www.compadre.org/per), was initially developed in partnership with Bob Beichner and continues with the help of the community at large. Community members provide PER dissertations, review articles, and information about research groups around the world. Information about the PER Topical Group and a PER-focused wiki are available. ComPADRE also hosts the online component of the annual Physics Education Research Conference (PERC). PERC abstracts, articles, posters, and schedules are available at the web site: (http://www.compadre.org/per/conferences/).

Meeting services provided by ComPADRE include abstract and paper submission and review. After the conferences, both papers and posters are available through the repository and linked to the proceedings.

Fig.4 – Roller-Coaster simulation (in East Java Simulations).

- One of our most productive collaborations is with the Open Source Physics project, an NSF-funded effort to advance computer modeling and the use of interactive simulations in physics and astronomy education. The OSP materials are built on the belief that computational models should not be black boxes, and that the development of graphically interesting physical models should not require years of java programming experience. The OSP developers focus on the improvement of their tools and simulations and let the ComPADRE staff provide the web dissemination and database development. The combination of the OSP programming library, the Easy Java Simulation modeling environment (http://www.um.es/fem/Ejs/), and disseminations through the ComPADRE library has proven very fruitful.

- The final collaboration has had the largest impact. When ComPADRE started, the Physics Classroom, (http://www.physicsclassroom.com) was among the most requested resources in the library, particularly by high school teachers. Unfortunately, in 2007 this widely used web site was in danger of becoming unavailable because of a change in the company hosting the public Physics Classroom tutorials. The Illinois high school where this material is developed could not handle the resultant traffic. ComPADRE now works with the author of this material to keep it available on the web. Figure 5 shows the number of visits to the Physics Classroom each week. Usage more than tripled from the first year of hosting to the second and has nearly doubled during the past year. The Physics Classroom is now being accessed by about 230,000 visitors per week. This is an example of ComPADRE's goal to meet the resource needs of physics students and teachers.

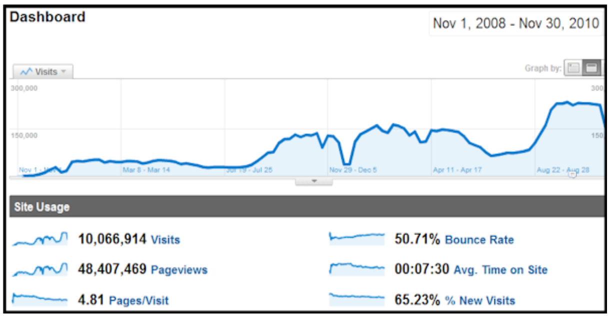


Fig.5- Weekly web traffic statistics for the Physics Classroom.

The Future

Predicting the future of web-based efforts is notoriously difficult, but I feel that the future of ComPADRE is bright. Increasing numbers of researchers and teachers have explored collaborations with ComPADRE as part of the dissemination of their work. Our project staff, although small, is creative and productive, our editors provide exciting new ideas and goals, and the ComPADRE society partners are a source of advice and support. There is always more content needed and we encourage everyone with suggestions or questions to contact us using the links at the bottom of every ComPADRE page.

Citation for the Presentation of the ICPE Medal to Professor Gunnar Tibell

Professor Emeritus at University of Uppsala, Sweden October 2009

The Commission is pleased to announce the award of the ICPE Medal for the year 2010 to Gunnar Tibell, Professor Emeritus at University of Uppsala, Sweden. An experimental nuclear physicist, he is well known for his contributions as the Chairman of the Swedish Physical Society 1989-95, and the European Physical Society, where he played an influential role with his strong advocacy for the cause of physics education at all levels. As Chair of the EPS Physics Forum and later within the Physics Education Division, he vigorously supported a wide range of educational activities, including pre-university education, student mobility programmes, international exchanges for physics teachers and student competitions.

He is especially known for spearheading the *International Young Physicists Tournament* for ten years as President from 1999.
See: (http://www.iypt.org/new/)
Prof. Tibell served as a member of ICPE from 1999 to 2002 and was Chair from 2002 to 2005. His deep engagement with EPS and other international physics organizations led to greater synergy that strengthened global exchanges for development of physics education programmes.

Established in 1979 on suggestion from George Marx, the ICPE medal recognises outstanding contributions to physics education that transcend national boundaries; are major in scope and impact; and have extended over a considerable period of time.

Prof. Tibell will receive the medal at a ceremony to be organized at the ICPE's conference in Mexico in August 2011.

ICPE Publications

On the occasion of the 50th anniversary of the commission, celebrated at Reims, we launched the print copy of the book *Connecting Research in Physics Education with Teacher Education, Volume II*, with Matilde Vicentini and Elena Sassi as general editors. The electronic version of the book has been freely available since 2008 at the commission's website. Volume I, with Andrée Tiberghien, E. Leonard Jossem, Jorge Barojasas General Editors, along with other ICPE publications, is also available for free download at this site.

Grants from IUPAP and UNESCO have enabled us to print copies in India at a reasonable cost. We will be happy to send copies of this valuable resource to individuals, institutions and libraries. Conference and workshop organizers, especially of events held in developing countries, are encouraged to seek copies for distribution to participants. To procure, write to me at icpe.chair@gmail.com.

PHYSWARE: Multimedia in Physics Teaching and Learning (MPTL):

Report of the 14th workshop held on 23-25 September 2009, Udine, Italy

Elena Sassi (University of Naples, "Federico II"), Italy

Background: PHYSWARE is an initiative designed to enhance the quality of physics education at the tertiary level, especially in the developing world, and was conceptualized as a series of workshops. It is a direct outcome of recommendations from the physics education task force of the World Conference on Physics and Sustainable Development (WCPSD) co-sponsored in 2005 by the International Center for theoretical Physics (ICTP), the International Union of Pure and Applied Physics (IUPAP), UNESCO and the South African Institute of Physics. The action plans, endorsed by all sponsors, emanate from the urgent need to strengthen physics education at all levels in all countries. These plans mandate development of model workshops and resource materials for physics teachers and teacher trainers that exemplify how active learning methods can be adapted to meet the needs of students in developing countries and, further, mechanisms for electronic sharing of high quality physics education resources by establishing a website.

Objective: Within this framework, the first Physware workshop was held at ICTP from 16 to 27 February 2009. It brought together a talented group of physics educators to collaboratively explore active learning materials at the undergraduate level using affordable hands-on equipment that can be locally adapted by teachers and their students throughout the developing world. Physware also aimed at providing an exposure to appropriate technologies and computer-based tools for enhancing conceptual understanding. For obvious reasons, teaching of Newtonian Mechanics was chosen as the theme for the first workshop.
Another important aim was to provide a forum to the teacher-leaders to share experiences and exchange ideas about dissemination of active learning methods as they are expected to become leaders of similar efforts in their local regions.

Participants: In addition to the ICTP publicity network, a concerted attempt was made by the directors to outreach physics education communities by distributing the workshop poster at several physics education events across the world, posting it on pertinent websites and newsletters such as that of the ICPE. More than 200 applications from 48 countries were received, and 32 participants were selected from 27 countries in Africa, Asia, Latin America and Europe. The Physware participants represent a multicultural but eclectic group of talented and innovative physics teachers, teacher-trainers and administrators with demonstrated potential for assuming leadership role in dissemination activities organization of similar workshops.

Introductory posters: Early in the workshop, the participants participate in evening poster sessions where they presented some of the innovative work done by them or some aspect of physics education in their institution or country. This served the dual purpose of breaking the ice and identifying areas of interest and work. The presentations also served to identify the large common denominator of problems faced in all countries.

Sessions: The two week workshop (10 working days) was structured to have four blocks of one hour forty five minutes on each day. Additionally, seven days included a two hour post dinner block to accommodate poster sessions and discussions. The participants were exposed to research based concept tests, diagnostic tools and learning cycles that promote active engagement. The first week activities, focused on laboratory work and class activities using no-cost and locally available materials, and saw development of several innovative measurement set-ups and procedures. For instance, pendulums of different lengths were used as clocks to measure time in arbitrary units and a mahogany flower pendulum was used to study damping. Later the ubiquitous cell phone provided a convenient mechanism for accurate measurement of time.
In the second week, the participants were exposed to computer-based measurement using motion sensors,

force sensor and photogates. Powerful video capture and data analysis tools were used to analyze video clips of interesting motions such as that of a thrown basketball. One session was also devoted to how simulations can be integrated into a learning cycle to enhance conceptual learning.
Additionally, two technical sessions were organized to introduce participants to a virtual instrumentation project ongoing at the ICTP M-Lab, and to the construction of communication networks using low-cost wireless technologies, which generated a great deal of interest. In another session, participants evaluated features of low-cost computers, including the much-in-the-news "$100" computer from MIT.

Projects: The touchstone of Physware was collaborative work on projects. In the first week, participants worked with low-cost material to explore their use in active learning of topics of core importance in mechanics and presented the work through posters. In the second week, projects judiciously used appropriate computer-based technological tools. These included the use of motion and force sensors, and photogates; video data and graphical analysis software; and free/open source software. As many as fourteen projects were carried out in the span of a day. All the groups made a Power-Point presentation. For example, one project evaluated effectiveness of the use of video capture and timing devices, to measure the time of free fall. Two of the projects entailed creation of proposals for workshops and a course in physics education for teachers. We hope some of this work can be refined for publication.

Special Discussions: A two hour evening session was devoted to discussing under-representation of women in physics. Participants shared informal statistics, country reports, personal experiences and fruitful interventions. Proceedings and resolutions emanating from the three IUPAP sponsored International Conferences on Women in Physics held at Paris 2002, Rio de Janeiro 205 and Seoul 2008, were shared. As a natural extension, issues of multicultural and multiethnic classroom were also discussed.
Participants also had discussions with the Associate Director and Director of ICTP, to apprise them on the problems of physics education in developing countries and the need for ICTP to initiate programs in the area. The group also deliberated separately to provide inputs to an action plan for consolidating Physware as a series of global and regional workshops.

Towards a community of practice: A highlight of the workshop was the creation of a Physware Discussion Group and a Blog —in addition to the Physware Workshop site at the ICTP portal and the Wiki created by the directors. Participants were quick on the uptake and used the sites for exchange of information, resources and discussion on several threads. One participant volunteered to be the webmaster and led the participants through a special tutorial on how best to use a blog.
Another session was devoted to discussing the establishment of community of practice to further learning and collaboration through the sharing of resources, experiences and best practices through structured communication. It was decided to request ICTP to facilitate use of a web-based system that would enable the formation of a Physware community to continue the collaboration forged at the workshop while working in their respective countries. This is essential if the group is to produce concrete outcomes that can be shared globally and impact regional practice of physics education in the long term.

Feedback and Evaluation: A measure of the success of this workshop is the immense enthusiasm and diligence with which the participants worked until late at night — 10 pm on most evenings, Feedback of the participants on formal evaluation forms has been extremely positive on all counts.

Future Plans: Physware has successfully established a primary network of outstanding physics teachers who familiar with best practices in physics education. They are enthusiastic about sharing their knowledge of active learning using low-cost materials and emerging technologies. They are anxious to find solutions to regional and local physics education problems. We are pleased that ICTP has agreed to maintain a website to facilitate formation of a Physware Community of Practice to strengthen local and regional outreach of participants.
Most participants plan to take a lead role in their regions and develop further the collaboration established with other Physware participants at a global level. There is an overwhelming consensus that ICTP should organize a series of Physware workshops on other introductory physics topics and also facilitate the organization of regional Physware workshops in developing countries. To move forward on these recommendations, the Physware directors plan to submit a five year action plan to ICTP for additional workshops, promotion of regional collaborations and development of the related Community of Practice.

Acknowledgments: We thank John Wiley & Sons, Inc., Prentice Hall, ICTP, ICPE and Indian Academy of Science for gift of books to the participants; Vernier International for gift of Logger Pro and some hardware; COACH AMSTEL for loan of equipment and gift of software; Physics Education Group at University of Udine for loan of equipment. We acknowledge the support provided by ICTP, IUPAP, UNESCO and the US National Science Foundation. We also thank Ms. Stanka Tanaskovic for the excellent logistic and administrative support.

International Conference on Physics Education 2011
"Training Physics Teachers and Educational Networks"
Mexico City, August 15–19, 2011

Physics Education is a cross-sectional discipline connected with almost all subjects in Physics. It is a recent research field on its own investigating the process of teaching and learning Physics with the aim to improve them. Many academics acknowledge the importance of Physics Education research and its role in exposing students' learning difficulties in Physics courses. In addition, difficulties in getting messages across on how important teaching and learning processes are to the success, and lack thereof, of the physics educational system at large have also been realized. There are two characteristic views in Physics Education using different scientific resources and methods but interconnected with each other in manifold ways: one directed to the Physics subject to be taught, the other focused on the student and his ability to learn and understand Physics. For this purpose researchers in this field have to cooperate with scientists from other disciplines like educational theorists and psychologists and with teachers, as well. But the main partners are physicists from the different areas of Physics. Therefore it is essential for the development of Physics Education that these scientists remain willingly to make appropriate contributions to this field and to cooperate with the science educators.

Importance of training physics teachers at all educational levels

Recent research in Science Education shows that teachers have ideas, attitudes, and behaviors related to science teaching based on a lengthy "environmental" training period, the period in which they themselves were students. The influence of this incidental training is enormous because it corresponds to reiterated experiences acquired in a non-reflexive manner as something natural, thus escaping criticism. In fact, it is not possible to change what teachers and pupils do in the classroom without transforming their epistemology, their conceptions about how knowledge is constructed, and their views about science.

On the other hand, we have the problem of Physics curricula. The contents and how those contents would be communicated among Physics educators students, teachers, and students are also of high importance and concern. Recently the ICPE commission has given a very important recommendation on teaching Physics, which is related with active learning methodologies and laboratory work. Then, it is necessary to assist Physics teachers at all levels to have access on Physics Education results. Also, use of Information and Communication Technologies are very important to start a big program on training Physics teachers in our region.

Important dates

- First Announcement August 22 2010
- 2nd Announcement December 1, 2010
- Pre-registration & Abstracts February 28, 2011
- 3rd Announcement & Final Program July 15, 2011
- ICPE (Mexico 2011) August 15-19 2011

You can find further details on the conference website

http://www.icpe2011.net

Adapting materials from different countries to combine experiments with visualizations

Dean Zollman
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For several years we have had a general goal of making the physics of the 20th and 21st centuries accessible to the students with limited mathematical skills and little science background. We try to focus the students' attention on why we understand and how we come to understand rather than just what the phenomenon is. Our method is based on the well-known results of physics education research. The students need to be actively involved in their learning. Further, they should learn about conceptual models. Our approach in recent years has been to use a combination of hands-on activities, written documentation, computer visualizations, videos and analogies which we put together in an active learning package.

To create a set of materials with all of these components would be a very time consuming task. Fortunately, web-based materials are readily available. These materials are sometimes created specifically for instruction but other times for informing the general public about research activities or even for entertainment. They can be combined in to an instructional package that draws from sources in different countries and helps show how students that conducting and understanding science is truly an international endeavor.

As an example I will describe the components of the study of electron diffraction experiment. This lesson includes a program that we created ourselves and the work of several groups, including a research level experiment and a commercial film animator. In this example I have used Web-based materials from Japan, Germany and the US. All of the components are available on the Web. With the links in this article you can try it yourself.

We use electron interference as the first introduction to the wave behavior of matter.[1] This approach is consistent with the research that indicates students gain from a concrete experience before the introduction of the theory. It is also similar to the approach taken by Feynman.[2] In this case the experience in the electron diffraction experiment and comparison of its results with those of a two-slit experiment with light. Thus, we usually begin with a look at two-slit interference patterns with light. The students look at the interference for a red light and then for a green light. The critical feature is observation of the change in the interference pattern when one changes from red to green light. We do not ask the students to make measurements or calculations – just notice how the pattern changes as the wavelength changes.

Now, we look at electrons. A difficult part for the instructor is to motivate why we might even want to look at electrons in an interference experiment. I do not have a good motivation, so we just do it. Of course, many universities have an electron diffraction tube. In that case the students can conduct the experiment. However, many do not have them. Fortunately two different computer-based arrangements enable the students to conduct an experiment.

The physics education group at the University of Kaiserslautern has a set of experiments which can be controlled remotely. The instructions are available in both English and German, so our students can complete the experiment. At http://rcl.physik.uni-kl.de/ students can select the electron diffraction experiment, enter a voltage and see the interference pattern on a real electron diffraction tube. Figure 1 is a screen capture of the remote experiment.

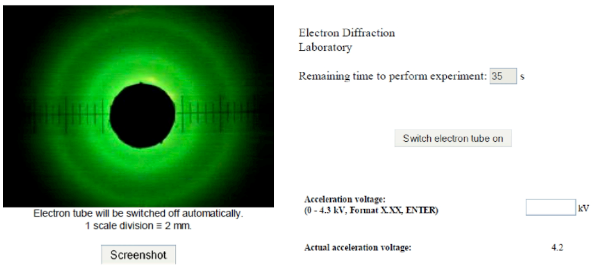

Figure 1: The approximate screen for the Kaiserslautern remote control electron diffraction experiment. (As they say on the airplane, it has been modified slightly to fit on the page.) http://rcl.physik.uni-kl.de/

For our students we have limited access to the electron diffraction apparatus. We have only two, and they are shared by several classes. As an additional experience our students do the remote control lab and tell each student, "Do four voltages and ship them to me by email and we'll put them all together in one class." Thus, we have a relatively large data set to look at in class.

An almost real experiment is interactive screen experiments. These types of experiments were developed in German under the name Interaktiv Bildschirm Experimenten or IBE[3]. A scrren capture of an IBE for electron diffraction is shown in Figure 2. These experiments involve a large number of individual still pictures. The pictures include essentially every configuration and variable setting that the developer could think of. Students can turn on the apparatus and conduct the experiment by turning the dials. They can then record the variables and the resulting interference pattern. The IBE can sometimes be frustratingly realistic. For example, I have set it up, turned the voltage dial and nothing happens because I forgot to turn on the heater switch. (Some IBEs require students to connect the wires; this one does not.)

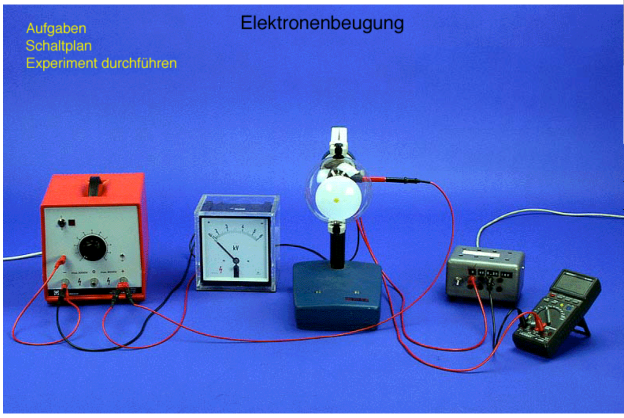

Figure 2: An interactive screen experiment for electron diffraction

Once students see that an interference experiment with electron is something interesting, we must introduce some of the principles related to the phenomenon. Our approach includes having students conduct several virtual two-slit experiments with electrons and other forms of matter. Using *the Visual Quantum Mechanics* interactive simulation (Figure 3) we establish the relationship between wavelength and energy of the particle. More details are presented in reference 1You can run the two-slit experiment at http://web.phys.ksu.edu/vqm/software/online/vqm/html/doubleslit/index.html

As a summary we have the students watch an animated sequence from *What the bleep do we know,* a commercial film with which most of our students are familiar. See http://www.whatthebleep.com.

(This scene is not the theatrical release of the movie. However, it is included in the extended director's cut which is five hours long. It is also posted on the movie's web site and YouTube, so you can avoid watching the 5-hour version.) I have my students by the way look for errors in this. For example, the single slit diffraction is not treated correctly in the film. By the time we get done with this most of them are able to find it.

(In the film, "Dr. Quantum" mentions items that we have not discussed yet such as wave functions. I ask students to keep a list of these ideas, so that we can discuss them later.)

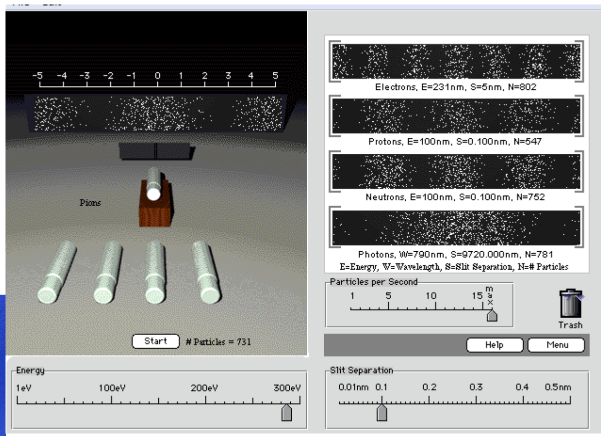

Fig. 3: Figure 3: A screen shot from the Visual Quantum Mechanics double slit visualization. Each of the white cylinders represent a "gun" for a different type of particle, electrons, protons, neutrons, photons and pions.

Another question that we address is, what happens if the electrons move through the one electron at a time. Our interactive visualization enables students to control the rate of particles. Of course, simulations can do anything, so we need to show some connection with reality. Fortunately, Tonomura, who is a research physicist for Hitachi in Japan has done the experiment[4] and put the results on the Web. A schematic diagram of his two-slit experiment for electrons is shown in Figure 4. A video of the individual electrons striking the screen and gradually building up an interference pattern is available at http://www.hitachi.com/rd/research/em/doubleslit.html

and on YouTube. Once students accept that this effect is real, we can start discussing difficult issues such as, "Does each electron go through one slit and then interfere (whatever that means) with another electron rather than interfere with itself?"

Returning to the visualization we repeat the one-at-a-time electron experiment and compare it to a similar photon experiment. However, you notice in Figure 3 that several other particles are available. Each of them is based on results of research which we completed in developing *Visual Quantum Mechanics.* In early versions we added only a nucleon so that students could investigate how the interference pattern varied with mass. However, we discovered that a common conception of students was that these particles were spreading out all of the electrons or nucleons have the same charge. Therefore, they were repelling each other. We now have protons and neutrons so that they can compare the charge dependence for particles of almost identical mass. Of course they see no such dependence.

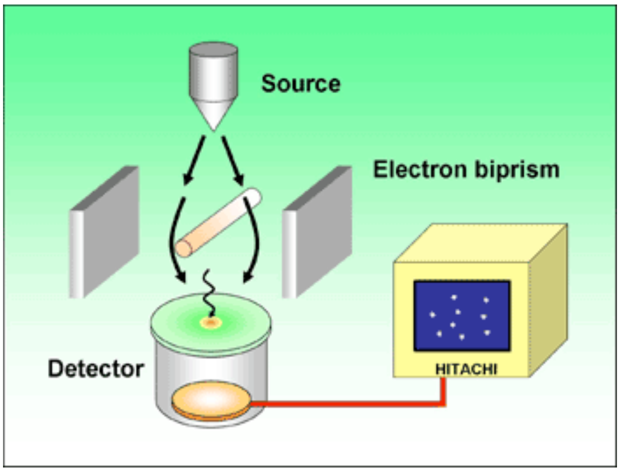

Figure 4. A diagram for the the equivalent of a double slit experiment for electrons. *http://www.hitachi.com/rd/research/em/doubleslit.html*

In this example, I have shown how an instructor can start this study of the wave behavior of matter with hands-on activities, even if you do not have the apparatus, Then introduce new concepts and have the students do further applications. This is kind of a basic learning cycle trying to build models as we go and in all of that use a combination of different types of learning materials. These materials provide both hands-on experiences similar to doing a real experiment and visualizations that help them construct models of the physical phenomenon. Thus, by collecting all of these materials in a lesson that is consistent with physics education research, we can provide a learning experience on a rather abstract topic.

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References

[1] D.A.Zollman, N.S.Rebello and K.Hogg, *American Journal of Physics, **70,** 252–259 (2002)*

[2] Richard P.Feynmann, Robert B.Leighton and Matthew Sands, *The Feynmann Lectures on Physics,* Vol.3, Reading Mass., Addison-Wesley Pub.Co. (1965) pp.1-2 – 1-9

[3] J Jürgen Kirstein, Meike Zastrow, Zum Einsatz Interaktiver, *Bildschirmexperimente (IBE) im physikalischen Praktikum* http://www.physikalische-praktika.de/dpgschule/2000/Programm/Abstracts/kirstein

[4] A.Tonomura, J Endo,T. Matsuda,T. Kawasaki,;H. Ezawa, *American Journal of Physics* **57** 117-120 (1989)

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