TRAINING OF STAFF FOR SCIENCE TEACHING CENTER

1. Mission

The mission of the SCIENCE TEACHING CENTER that this project is about, is to develop and foster permanent contacts and collaboration between teachers and scientists. It is imperative to us that to achieve required progress in education teachers of science and scientists need to join their forces and create opportunities for applied research and development that can bring real benefits to all students. Scientists will contribute their knowledge and understanding of science, and fine methods of academic training, while teachers will contribute their knowledge of the school realities and students' needs. Together and with mutual understanding, they will be able to develop the skills of best teaching that help students become interested in science and conscious self-development, no matter what their carriers are to be. As a result of the collaboration with scientists, teachers will be able to apply principles of scientific reasoning in their work at school, and focus on programs that catch kids and help them succeed. The CENTER will make all efforts to win recognition by teachers around the country as an outstanding source of expertise and exemplary materials for teaching science at school. The key measure of the program success or failure will be whether or not the Center will be established and working efficiently in 2003, with accreditation by the Polish Ministry of Education.

Operation of the CENTER by members of the Warsaw Branch of the Polish Physical Society, will be a natural part of and continuation of the tradition of the Society, which was created in 1920 and belongs to the European Physical Society. The Polish Physical Society has about 1800 members and 3/4 of them are scientists, including the best Polish physicists. Its mission is to help in progress in physics and enhancement of public appreciation of physical sciences, to strengthen connections between physicists working in education, science and industry, and to represent the community of physicists. The Polish Physical Society web page has address http://www.fuw.edu.pl/~ptf.

2. General description of TRAINING OF STAFF FOR SCIENCE TEACHING CENTER

The idea of the SCIENCE TEACHING CENTER was conceived by a team of members of the Polish Physical Society after 5 years of voluntary work. The work included experimental classroom courses on basic concepts in physics, delivered mainly by scientists for teachers and students. These courses were based on hands-on experiments, which are closely related to every day life and carried out using very simple, mostly self-made equipment. We put emphasis on independent inquiry of the students, and their collaboration in small teams. We have attempted to understand how to initiate and support students' interest in learning science, and how to help teachers in developing their own skills in science and teaching so that their contact with students could lead to productive learning and authentic skills of scientific reasoning. A lot of children and adults admited that the Discoverers' Club influenced their attitude to teaching and learning. "Inquiry is difficult, but it gives satisfaction". "The most important was that I learnt not to be afraid to fail, so I could concentrate on the subject in physics". "I worked it out myself, that my assumption was wrong, and this is the way I got interested in". "I realized that my way of teaching was not perfect. The classes showed me how to make learning more colorful and more interesting for the students".

The plan of creating a SCIENCE TEACHING CENTER was worked out in detail after we have gathered experience from leading a Discoverers' Club in Warsaw in 1995-2000, training 23 adults and 100 students in 395 hrs of experimental classroom courses, led by 7 instructors.

The team also studied the Ohio project "Discovery" that trained about 5000 teachers and reached this way all their students. This project was very successful in teaching science, as can be found from his leader, Kenneth G. Wilson, Nobel laureate for physics, a professor at the Ohio State University in Columbus, Ohio. But Discovery did not create a permanent center for teachers to continue their work on improving their repertoire of skills and knowledge of science, perpetually in collaboration with scientists. Our plan is to create such a place for teachers. To this goal, we need a larger team than we used to have so far. We ask The ... Foundation to support a two-year training program for a group of teachers, scientists and graduate students who will join the team and form the first staff of the SCIENCE TEACHING CENTER.

Proceeding at much smaller scale than Discovery, we could learn about the great value Discovery provided to teachers, which is familiarity with basic skills of reasoning and productive learning inherent to scientific research, so that teachers can approach problems they encounter in teaching students with similar attitude. We have learned how to use materials Discovery was using and we have also learned how much effort it requires to create new materials for students. To do it effectively, in-service teachers need a collaboration with scientists.

But most importantly for this project, we found that no systematic growth of the educational reform activity can be assured for the real benefit of students, unless teachers and scientists find and exploit natural ways of collaboration for them, and with local self-sustained support. This was not achieved by Discovery, and its operation was not sustained, as it happens with majority of projects after some time, usually about 5 years, even if successful. As a result of our efforts, and to fill the observed gap in our case, four people prepared this proposal.

The main result of our studies is that the most inspiring example of effective teaching method, and a guidebook to deep understanding of basic concepts in science, is the book by L. McDermott and Physics Education Group from University of Washington, "Physics by Inquiry". The method is based on students' own construction of scientific models of phenomena they learn about through asking questions, carrying out experiments with their own hands and drawing conclusions from the outcomes in accord with principles of scientific reasoning. The textbook is a result of more than 20 years of research and tests carried out by about 40 people, and it has 800 pages. The textbook was translated into Polish by instructors of the Discoverers' Club.

The SCIENCE TEACHING CENTER should open in the academic year 2002/2003 by delivering courses for a considerable number of teachers on the basis of McDermott's book. In its subsequent operation, in which alumni of the courses will participate as the staff and apprentices, the CENTER will be creating new generations of materials, with a wider scope and including more advanced subjects, and it will be disseminating those, too, in additional courses, through Internet, and by publications.

Launching of the CENTER in 2002/2003 academic year requires that we already now involve in our work a considerably larger team of people than we have so far. We estimate on the basis of our experience that the core of the team must include about 12 scientists and teachers who understand each other very well. A similar number of people are needed to help in the daily operation of the CENTER by the core group, and we also need people who know the CENTER very well and can help in communication with schools, other science education centers and local administrations.

The two-year training program is essential, for every member of the team must be familiar with the McDermott book in practice, having worked through at least three sections on different subjects as a student. Each and every member of the team must give a set of lessons using the McDermott book, or their own materials with similar characteristics. The project Discovery and our Discoverers' Club imply, that to understand the essence of teaching using textbooks such as McDermott's, teachers need to work with it for about 150 hours. Every member of the team must also participate in preparation of the CENTER operating plan for the first years. The training program must include the design process in order to enable new members of the program to learn about realistic options for effectively helping other teachers in their classroom work.

3. Program details

Goals and purposes

The TRAINING OF STAFF FOR SCIENCE TEACHING CENTER (TSSTC) is necessary for launching the Center in 2002/2003. The CENTER is to provide a permanent institutional basis within Polish Physical Society, for exchange of ideas and sharing educational experience among teachers, between teachers and scientists, and among scientists. This is the necessary condition for creating a living environment for progress and developing the repertoire of skills, knowledge and materials that are required to serve students' needs of productive learning at school. The final outcome of this project will consist of an application of the Polish Physical Society to the Polish Ministry of Education for accreditation of the Center. The application must contain lists of names of teachers and scientists who form the first staff of the Center. This step will conclude this 2 year program and, at the same time, it will open the operation of the Center for indefinite time. The accreditation is required for the Center to operate in the existing school system and to provide services to teachers with support from their authorities or foundations. The TSSTC program will also result in creation of teaching materials and a Web site where the Center will be accessible for all teachers.

What has been already done

The Discoverers' Club 5-years activities were focused on science teaching experiments in a number of different settings. The main focus was put on testing and adjusting to the Polish culture the science cognitive learning methods developed by McDermott and the Physics Education Group at the University of Washington. The SCIENCE MODULES offered by the Discoverers' Club to scientists, teachers, students (from middle and high schools), and their parents, are listed in Table 1. Our experience shows that demand for the SCIENCE MODULES certainly exists. However, the percentage of voluntary participants who resigned typically varied between 55%-85%. The main reason is the gap between the present school curriculum and the contexts of scientific reasoning; students do not have time for understanding as much as they are required to learn at school,

they limit their effort too often to merely memorizing parts of the material for the period of tests or exams, and they do not have habits of productive learning. Therefore, the Discoverers' Club staff attempted to create a culture of learning in the Club, which would help in overcoming this gap. This attempt has been clearly successful, as is shown by the growing numbers of instructors and their voluntary teaching hours, displayed in Table 1. It makes sense to share this success with many more people.

Table 1. The Discoverers' Club SCIENCE MODULES, 1995-2000

year	subject	number of hours	number of participating adults	number of participating children	number of staff
1995/1996	measurements of matter temperature and termometers astronomy at summer camp	83	–	32	3
1996/1997	electric circuits astronomy at winter camp astronomy by sight	84	20	26	2
1997/1998	optics	24	5	–	1
1998/1999	electric circuits temperature and termometers magnets	68	–	17	5
1999/2000	electric circuits mass and balancing optics Archimedes law $E = mc^2$	136	3	35	6
Total		**395**	**23**	**100**	**7**

Experience with teaching in the areas of the listed subjects resulted in a set of new written instructions with questions and comments (a "laboratory textbook"), to guide students in their independent work. Some of these materials can be used by teachers directly in their classroom programs. And the Discoverers' Club instructors became also authors of other unpublished science modules, which they still test in their professional teaching:
St. Głazek, T. Masłowski, M. Więckowski, *Renormalization in quantum mechanics*, Warsaw University, 1996/97.
St. Głazek, *Elements of theoretical physics*, Warsaw University, 1998/99 and 1999/2000.
M. Ekiel-Jeżewska, *Hydrodynamic interactions between two spheres, with lubrication and solid friction phenomena*, Ecole Superieure de Physique et de Chimie Industrielles de la Ville de Paris, 1997/98.
M. Ekiel-Jeżewska, *Hydrodynamic interactions between many spheres*, Ecole Superieure de Physique et de Chimie Industrielles de la Ville de Paris, 1997/98, http://xxx.lanl.gov/abs/physics/9811042.
M. Ekiel-Jeżewska, *Mathematical methods of science*, College of Science, Polish Academy of Sciences, Warsaw, 1999/2000.
A. Smólski, *Physics at secondary school*, Komorów, 1999/2000.

This set shows what we aim at for teachers and students at all levels, not only at schools, but also at teachers colleges and universities. The set contains materials that would never have been created if the authors were not engaged in the work of Discoverers' Club. The experience and understanding they developed in that voluntary work allowed them to create new materials in new areas and use them in new ways in their classrooms. The Discoverers' Club fostered their professional development.

The Center will serve as a home and hub for such activity on gradually growing scale, with the rate of growth in check with teachers' needs and the results of their work with students, as measured by performance on specially designed tests.

Training of Staff for Science Teaching Center 2001/02-2002/03: objectives and activities

The objective of the TSSTC program is to teach concepts of productive learning, based on scientific reasoning, and develop skills required for effective teaching. Following the Project Discovery, the TSSTC program adopts L.C. McDermott's "Physics by Inquiry" (Wiley, New York 1996) as its core. About 180 hours of training is estimated to be necessary to prepare the staff for facing challenges of the CENTER. This exceeds 150 hours that was found to cause sustained improvement of teaching habits for Discovery teachers in Ohio. The history of our Discoverers' Club has also indicated that it takes more time to train teacher leaders than teachers. The core of the TSSTC program will be combined with reading literature on basic issues of relevance to the SCIENCE TEACHING CENTER, such as critical thinking in science, psychology of learning, and principles of change in

social systems. The repertoire of teaching skills the Center will exist to develop fully agree with the standards used by the US National Board for Professional Teaching Standards.

In the FIRST YEAR of the program, the TSSTC team, consisting of the Discoverers' Club leading group, will organize a recruitment process and guide a training program, 3 hours per week, for 24 scientists, teachers and graduate students. The alumni best prepared for that role will participate in an advanced training in the second year and they will design the Center details with the initial group of instructors, and form the first staff together with the instructors. 8 such alumni of the first year is the minimum we need. There may be more, with all alumni helping in the project and everybody having a chance to contribute.

The initial number of participants needs to be at least 3 times larger than the minimal number of the actual future staff members because of two reasons. First, The Discoverers' Club statistics indicates that the average ratio of deeply engaged participants to the total number of participants is about 1/3 (for various courses, this ratio varied between 15% and 45%). Second, the still eager but less engaged participants are gaining experience with the process of learning and principles of scientific reasoning, and they become aware of the values the CENTER can bring to teachers, and through teachers to their students. A large number of such people are needed to disseminate the SCIENCE TEACHING CENTER vision at universities, teacher unions and schools. However, we cannot invite too many people at once. To provide the best quality of training, each of instructors should not have to take care of more than 6 participants, e.g. 3 teams of 2 persons each.

The trainees will work with the educational materials already extensively tested in Discoverers' Club, i.e. on measurements of matter, electric circuits and astronomy by sight. The trainees will be expected to prepare their own science modules for school children, and to test them in practice. Such modules will belong to their portfolio of the training outcomes. The 8 trainees, together with 1 person from TSSTC team, will organize a 10 days summer science camp for about 30 children, with 2 hrs of scheduled astronomy lessons and 1 hr of facilitated discussions on the teaching processes and their outcomes per day, leaving considerable room for constructing a sundial and performing the observations of stars and the Moon.

The SECOND YEAR of the program will be devoted mainly to design of the SCIENCE TEACHING CENTER, and to all arrangements that the Polish Physical Society needs to make to operate the accredited Center successfully. The advanced training of the 8 participants graduated from the first year, based on our experience with Discoverer's Club and lessons from Discovery, will also include instructing the courses based on "Physics by Inquiry", 3 hours per week, for a new group of 32 teachers, scientists and graduate students, with the assistance and supervision of the TSSTC instructors. For the purpose of further professional development in the Center we have already initiated and intend to design in all detail new materials for studies by teachers, on advanced subjects of special relativity and quantum mechanics, where adults meet challenges similar to the challenges their students face at school. This way adults learn new ways to approach problems of education. We also plan two visits of leading teachers to internationally recognized USA centers for professionalization of teaching.

The TSSTC team of instructors responsible for the program

Maria Ekiel-Jeżewska, born 1957, physicist, Ph.D., habilitation, Institute of Fundamental Technological Research, Polish Academy of Sciences.
Stanisław Głazek, born 1957, physicist, Ph.D., habilitation, Institute of Theoretical Physics, Physics Department, Warsaw University.
Magdalena Skompska, born 1957, chemist, Ph.D., habilitation, Department of Chemistry, Warsaw University.
Adam Smólski, born 1955, teacher of mathematics and physics in high and secondary school, Ph.D., the author of a textbook on mathematics, the editor-in-chief of the Polish journal for teachers "Physics at School".

Ekiel-Jeżewska, Głazek and Skompska translated into Polish 3/5 of "Physics by Inquiry" by L.C. McDermott.

4. Program budget and narrative

The budget narrative is provided in the form of two attached tables that explain and summarize expenses of the two years of activities, correspondingly (please see the tables).

BUDGET 1st YEAR	November	December	January	February	March	April	May	June	Total USD
1. Salary and fees									
4 Instructors									
-preparation of teaching materials (12 USD/hour)	432	432	288	288	576	432	576	288	**3312**
- teaching hours (8 USD/hour)	192	288	192	192	384	288	384	192	**2112**
accountant (10 USD/hour)	80	80	80	80	80	80	80	80	**640**
secretary (10 USD/hour)	80	80	80	80	80	80	80	80	**640**
2. Fringe benefits									
Insurance for 4 instructors	12	12	12	12	12	12	12	12	**96**
3. Consultants									
consultant for programme (44 hours, 20 USD/hour)	440	440							**880**
lawyer (22 hours, 20 USD/hour)	440								**440**
consultant for management (20 USD/hour)	440		200						**640**
consultant - Prof. S. Sarason, Yale U.-evaluation							3000		**3000**
4. Printing and publishing									
text books for course participants (35 x 5 USD)	175								**175**
advertisement leaflets (200 copies x 2 USD)	400								**400**
5. Media costs									
advertisements in newspapers (5 x 30 USD)	150								**150**
short article/interview in a newspaper							350		**350**
design and preparation of Web site		200	100		100		100		**500**
6. Telephone	20	20	20	20	20	20	20	20	**160**
7. Supplies (purchasing of books)		100		200		50			**350**
8. Postage	20	10					20		**50**
9. Other									
stipends for 24 participants (5 USD/hour)	720	1080	720	720	1440	1080	1440	720	**7920**
cost of classroom renting	90	90	90	90	90	90	90	90	**720**
equipment used in the course	60	45	30	30	60	45	60	30	**360**
Total									**22895**
10 days camp in summer (for 30 children)	**July 2001**								
1 co-ordinator (salary: 40 USD/day)	400								**400**
8 teachers (salary:10 USD/hour; 3hours/day)	2400								**2400**
8 teachers+coordinator (accommodation+subsistence)	2700								**2700**
teaching materials (8 USD/participant)	240								**240**
TOTAL 1st year									**28635**

2nd YEAR	October	November	December	January	February	March	April	May	June	Total USD
1.Salary and fees										
8 Instructors										
-preparation of teaching materials (12USD/hour)	960	960	672	480	480	960	672	960	480	**6624**
-teaching hours (8 USD/hour)	768	768	576	384	384	768	576	768	384	**5376**
4 co-ordinators (organisation of STC: 20USD/hour)	960	960	720	480	480	960	720	960	480	**6720**
accountant (10 USD/hour)	80	80	80	80	80	80	80	80	80	**720**
secretary (10 USD/hour)	80	80	80	80	80	80	80	80	80	**720**
2. Fringe benefits										
Insurance for 8 instructors	24	24	24	24	24	24	24	24	24	**216**
3. Consultatns										
lawyer		450								**450**
consultant for advertisment	200						200			**400**
4. Printing and publishing										
text books (40 x 5 USD)	200									**200**
advertisement leaflets (100 items x 2 USD)	200									**200**
5. Media costs										
advertisements in newspapers	100									**100**
updating of the Web site (10 USD/hour)	50	50	50	50	50	50	50	50	50	**450**
6. Telephone	20	20	20	20	20	20	20	20	20	**180**
7. Supplies (purchasing of books)		100				50				**150**
8. Postage		20	10					20		**50**
9. Other										
stipends for 32 participants (5USD/hour)	1920	1920	1440	960	960	1920	1440	1920	960	**13440**
cost of classroom renting	90	90	90	90	90	90	90	90	90	**810**
equipment used in the course	60	60	45	30	30	60	45	60	30	**420**
two visits of instructors for training in USA	5000									**5000**
TOTAL 2nd year										**42226**

TOTAL BUDGET OF THE PROGRAM (two years) **70861**

Text book (about 120 pages): a book of laboratory instructions for use by participants, recording the results of experiments, observations and reasoning.

Advertisement leaflets: prepared to disseminate information about activities of ScienceTeaching Centre (STC) by sending them to schools teachers

Web site: The activity of the STC will be reported on Web site and some exemplary materials will be available for teachers, to help them in sharing their experience in novel teaching methods and resolving problems in their work.