Experiences from long-term in-service training for physics teachers in Finland

Johanna Jauhiainen[1], Jari Lavonen[2], Ismo Koponen[1] and Kaarle Kurki-Suonio[1]
[1]*Department of Physics and* [2]*Department of Teacher Education, University of Helsinki, Finland*

Abstract

We describe here a long-term in-service training program for physics teachers (grades 7 - 12) designed to enhance teachers' subject matter and pedagogical content knowledge. Teachers' opinions of the program have been examined with a survey. Results suggest that most valuable for the daily teaching profession were those courses and activities where teachers had possibility to co-operate, reflect and plan with each others in small groups.

Introduction

In Finland one of the main goals in science educational policy in years 1990 onward has been to raise the level of scientific and mathematical knowledge and skills of pupils. One of the approaches suggested is long-term in-service training programs for teachers in mathematics and science. Experimental approach is mentioned as one solution for better learning in Physics in the national guidelines for school curriculum by the Finnish National Board of Education (NBE 1994,p. 96). It has repeatedly been recommended that the role of demonstrations, practical work, and experimentality in general, should have a more important role in science education (LUMA 1999)

One effort to meet these goals has been the project, *In-service Training for Physics Teachers* (ITPT), which is a long term, 30 ECTS -credits in-service training program for physics teachers in lower and upper secondary school (grades 7 – 12). The project was organised on the basis of physics teacher's pre-service training program at the department of physics. In *ITPT,* as in many other projects where teachers' professional development (e.g., Solomon and Tresman 1999), collaboration between teachers and reflection was supported. Therefore we encourage teachers through different exercises, discussions in small and big groups to inspect their knowledge and experience, share their experiences, reflect on the present teaching and attempted to improve the nature of their approach to teaching. Here we describe and outline the main features of the *ITPT*, and evaluate it from the point of view of its meaning to the teachers' daily work. The evaluation is based on data gathered by a questionnaire.

In-service Training for Physics Teachers - project (*ITPT*)

The In-service Training for Physics Teachers – project, *ITPT*, was initiated at the beginning of August 1996. The project has been organised twice, in 29.7.1996 - 31.12.1997 and 6.3.1998 - 31.12.1999. A third project was started at 2000. It has been a rather extensive complementary education project where 207 lower and upper secondary school physics teachers participated from all over Finland. During the project one professor, two university lecturers and two assistants gave lectures and guided working in small groups.

The aim of the *ITPT*-project was to develop teachers' content knowledge, most importantly understanding of the structure of physics, concept formation, its methods and epistemology.

Equally important was the 'pedagogical content knowledge', which includes knowledge about the types of difficulties that students experience, typical paths that students must traverse to achieve understanding and potential strategies for helping students overcome learning obstacles, all of which are discipline-dependent (compare e.g. with Schulman (1987) and Mestre (2001)). Special attention was devoted to experimental teaching approach and the role of experimentality (meaning here e.g. demonstrations, practical work and investigations) in physics education in general and especially how experimentality can help students to understand the meanings of concepts, and promote conceptual understanding. Another goal is to show, how through experimentality, a network of laws of physics is established and how it acquires a central role in bringing coherence in the knowledge structure of physics. Also other educators have recently stressed the importance of these aspects in training physics teachers (Mestre 2001). Experimentality was connected to more general discussions about the epistemology, ontology and history of physics during lectures, seminars and discussions in small groups. This kind of approach can be expected to be a viable way to promote successful changes in teaching and learning physics (cf., Anderson and Mitchner, 1994, pp. 32-37). Consequently, teaching approach based on experimentality was introduced and it was practised with the teachers during training program.

In addition to the above mentioned goals, one underlying task of the project was to help the participants to become conscious, and to question, the teaching philosophy, the thinking habits and the fixed instructional practices they have assimilated in their profession. This consciousness, we believe, is required to motivate the change and improvement in ways of teaching and in instructional practices.

Training in the *ITPT* was organised according to the principles of open and distance education. The contact training was divided into several parts. There were 196 hours lectures and 44 hours seminars during the contact training periods in summer and at the weekends. In addition a large part of this long-term training was self-directed, distance-guided work in groups of two or three teachers at their school sites. Distance learning was supported through an e-mail-list, personal e-mail- discussion and chat sessions. Teachers had the possibility to co-operate and discuss in small groups and reflect or study what they really know about physics and physics education, what kind of practises they have in their classroom and what they learned during the training. This kind of reflection is regarded as important part of learning (Gunstone 1999, Briscoe and Peters 1997) because it is known that teachers tend to teach as they were taught (McDermott *et al.* 2000, Stein 2001). It is difficult to recognise and change the established practices without conscious self-reflection. Towards this end teachers produced in small groups for example concept maps before lectures and returned them to the lecturer before lectures and wrote self-evaluations of their learning process during the laboratory course (see in detail later). This, among other teaching methods in different courses during the ITPT, was hoped to help the adoption of new teaching methods through in-service training, which is known to be a difficult task (Fullan 1991).

The *ITPT* project consisted of four separate but closely connected courses.

1. *Principles of Concept Formation (PCF)* is a course that introduces central notions of the physics knowledge structure, its epistemology and methodology. Its purpose is not to teach more physics but to organise what have already been learnt. The main theme of the course is the analysis of interplay of theory and experimentality in the concept formation in physics, and what are the different possible ways to approach physical knowledge. Learning and

scientific inquiry are seen as different phases or levels in creating knowledge. During the course the teachers prepared 28 study-reports (summaries) for each 2-hour lecture. Ideas discussed during the lectures were applied in seminars (14) to problems of teaching and learning of physics in school. The evaluation of the course was based on study-reports.

2. *Conceptual and Processual Structures of School Physics (CPSSP)* analyses the conceptual and processual structures of the main areas of school physics. Attention was paid to the development of the hierarchy of concepts, laws and physical principles as it arises as representation of empirical meanings. This kind of knowledge, typical for experts, is needed for example in planning physics education, and especially in guiding students' problem solving (Mestre 2001). Concept maps developed during the course systemically supported the learning in CPSSP. Preliminary concept maps for each physical theme (e.g. electric circuit, absolutism and relativity) were prepared before lectures (56 hour) and developed further during group sessions.

3. *Experimentality in School Laboratory (ESL)* introduces the methods to plan and carry out experiments and demonstrations. Participants planned in small groups 10 structured experimental teaching units (e.g., waves, cause and effect in mechanics), in which each experiment contributes to the concept formation process. The teachers also learned how to use demonstration equipment, including data-logging methods. Teachers became trained in organising practical work, demonstrations and investigations. They learned how qualitative experimentality (observations and classifications) helps students create meanings for concepts. Furthermore, teachers practised quantitative experimentality and especially graphical presentation of the data. According to the feedback and preliminary plans for laboratories or demonstrations the group planned and carried out typically 5-10 qualitative and 5-10 quantitative experiments in one entirety in their own schools. Final reports consisted of descriptions of the demonstrations and the practical work. During the writing process teachers got feedback from the supervisor by e-mail. Evaluation was based on final reports and teachers' self-evaluation of the working process.

4. *History of Physics* (HP) was a course, which guides to identify the similarity of the processes of learning and scientific inquiry and to utilise the knowledge of historical concept formation in physics teaching. Altogether there were 56 hours lectures and 22 hours seminars. The evaluation was based on seminar presentations (average 30 pages) and a final examination.

Among materials that were given to the teachers were the book "The Meanings and Structures of Physics, MSP"(Kurki-Suonio K. and Kurki-Suonio R. 1994), and series of 8 physics books (Lavonen *et al.* 1994) written according to the principles described in the MSP. A series of textbook was originally published to help the students at upper secondary school to learn not only the basic concepts, laws and theories but also how their meaning is formed by experimentality.

Impacts of the training in *ITPT*

Two years after concluding the *ITPT I* and one year after the *ITPT II* we made a survey to find out what was the teachers' opinion of the project and its usefulness from the point of view of their daily teaching profession. In order to examine teachers' opinions a web-based questionnaire with 15 closed and one open question of studying in the project was prepared. Furthermore, we sent a paper version of the questionnaire to those teachers who had difficulties to answer through the Internet. The answers to the open question were analysed by building up categories and classifying the answers into them.

The teachers were asked to participate in the research through an e-mail-list. After the third reminder, a total of 98 teachers (58 % female) replied. They had an average of 16 -20 years of teaching experience and 48% of the teachers were working at lower and 16 % upper secondary school and others e.g. at vocational schools, local administration commission or headmasters. The teachers taught physics on average 0 - 5 hours, mathematics 6 - 10 and chemistry 0 - 5 hours a week. 74 % of the teachers had a Master of Science (M.Sc.) degree and 23 % a B.Sc. degree. 22% of the teachers had physics, 16 % chemistry and 36 % mathematics as a main subject.

The teachers were asked to evaluate the courses and the studying methods at the courses regarding to the usefulness of it in the every day work at school. The results are presented in figure 1.

Figure 1. Teachers' opinion of the courses and other activities at the in-service training during *ITPT*-project from the point of view of their daily teaching profession.

Nearly 80 % of the teachers answering the survey think that all lectures and seminars or exercises were at least of some advantage from the point of view of their daily teaching profession: planning lessons, making demonstrations, guiding students in problem solving etc. Most valuable for teachers from the point of view of their teaching profession were activities in the course *Experimentality in School Laboratory (ESL).* About 70 % of the teachers were of the opinion that working in small groups, discussing, planning, making measurements, writing reports from their own projects were of advantage and helped them develop their teaching profession. The course *Principles of Concept Formation (PCF)* with emphasis on the philosophical background of the ideas was considered to be least useful.

Informal comments about the program and the effects of it to their daily work were also asked. The teachers were not asked to give any general evaluation of the *ITPT* -project, but they were just asked to give informal comments about the effects of the in-service training program to their daily work. 29 gave no answer to the question. The answers were classified into 4 categories:

Change in the teaching style: Answers of 17 (17 %) teachers were interpreted so that they had adopted a totally new approach to their teaching where attention is given to the role of experimentality. This can be illustrated with the following quotations:
- The program has affected very deeply my teaching – I have got a totally new view.
- My teaching style changed. I realise now the connection of things and that you have to have a ground on which you can build up something new.
- I use the experimental approach more.

New element in teaching: 53 (54 %) of the teachers who answered the survey mentioned that they had taken new elements, introduced during the *ITPT* -project, to their physics teaching. Most popular new elements were concept maps (31 teachers), stories from the history of physics (22 teachers), new laboratory works (18 teachers) and student summaries or reports (13 teachers). 24 of the teachers mentioned two or more new elements they had adopted. Some examples are:
- Many practical works, which I have never carried out before, inspired me.
- From the course I caught many new demonstrations borrowed from somebody else or discovered by myself.

- The shortcoming of my teaching, for many years, has been the poor knowledge in the history of physics. The project improved my knowledge and gave me encouragement to a continuous hobby, to use the view of history in teaching physics.
- I had read something of concept maps before the project, but only after the course I had courage and motivation to use them in my teaching.

Learning more physics and professional development: 19 of the teachers mentioned spontaneously that they had learned physics and 25 of the teachers were thinking that they had developed in their teaching professions. It was mentioned for example that:
- I learned much new from modern physics.
- The program contributed mostly to my maturation as a physics teacher.
- My professional skill became strengthened a lot, when I recognised my abilities and limits.

In addition 4 of the teachers started to evaluate their teaching or wanted to learn more about physics and physics education. This can be illustrated with the following quotation:
-The program inspired me considering closer and developing my teaching.

Others: 4 of the teachers mentioned about the inspiring atmosphere at the project. On the other hand 5 of the teachers felt that they did not learn anything during the *ITPT* -project. This can be illustrated with the following quotations:
- I expected much more from the course than I finally got from it. The training was mostly traditional lectures, or rather thinking aloud. Mostly the lectures were overpowering to my capability of thinking.
Still it (experimental approach) *seems to me that it is more like a religion than a method that you truly can apply in the school.*

In summary, around 80 % of the teachers who answered the survey were of the opinion that all lectures and activities in small groups during the *ITPT* were of some or plenty of advantage to their teaching profession. About 70 % of the teachers were of the opinion that working in small groups, discussing, planning, making measurements, writing reports from their own projects were of advantage and helped them develop their teaching profession.

On the basis of the survey17 % of teachers who answered the survey reported they had adopted a new approach with emphasis on the role of experimentality in concept formation. 54 % of the teachers mentioned that they had taken new elements (concept maps, stories from the history of physics, new laboratory works and student summaries or reports), introduced during the *ITPT* -project, to their physics teaching.

Discussion and conclusions

The *ITPT* introduced basic epistemological and ontological aspects of physics, history of physics and, moreover, practical work and demonstrations including data-logging methods in physics education. It turned out that teachers valued most the courses *Experimentality in School Laboratory (ESL)* and *Conceptual Structures of School Physics* (CSSP). These courses focused on activities that teachers considered having plenty of advantage and helping them develop their teaching profession. This is to be expected, because both courses quite near the subject matter and pedagogical content knowledge teachers need in their daily work. Also studying the history of physics was valuable for teachers for same reasons. It seems that teachers adopted in the course *History of Physics* (HP) new elements in their teaching and how to make physics more interesting and relevant by including history and society issues in physics courses. The responses to the survey indicate that teachers use now more stories or other activities connected to the history of physics.

During ESL and CSSP teachers work, collaborate in small groups and learn from each others but also get information from their supervisor when it was needed. This approach helps teachers to develop strategies they can apply in school practice for helping their students to understand meanings of the concepts. Moreover, during both courses teachers had to reflect, study what they already know from the area to be studied: within CPSSP they made preliminary concept maps before lecture and within ESL they wrote preliminary plans. We selected this kind of approach because we wanted teachers to learn how important it is to reflect and to become aware of what one already knows about theme to be discussed. This was one way to introduce the teachers the ideas of pedagogical content knowledge. The teachers have to experience how important it is to discuss with colleagues, organise ideas using e.g. concept maps, and write project plans before lectures and seminars. This approach show the teachers how they can direct their students in construction of shared meanings with other students. Moreover, it underlines in learning the role of a teacher who knows the structure of physics, nature of cognition as an adaptive process and what the students already knows (Novak 1989, pp. 5–27). Furthermore, one reason for great value of CPSSP might be that during the course teachers become familiar with the concept maps, which they can use with their own students. In summary, during *ITPT* teachers were most interested to reflect, discuss and develop new laboratory activities in small groups.

On the other hand the teachers were not so interested in general approaches connected to the philosophy of physics and physics education. Discussions of the ontological and epistemological nature of physics and physics education and especially the role of experimentality in concept formation during the course PCF was not considered as valuable as other activities during the *ITPT*. Obviously teachers preferred practical, and readily usable elements of the *ITPT* because they are closer to their everyday needs than philosophical ideas and principles that could also be applied to school practice as learned during the seminars and group discussions.

About 50 % of the teachers had adopted new elements that were used as teaching methods during the *ITPT*. Therefore, physics teaching and learning in K-12 can be developed through different effective teaching and learning approaches in university physics education. (McDermott *et al.* 2000, Stein 2001). Moreover, according to feedback collected from the teachers it was important that teachers were given series of textbook and other learning materials where they can see examples how to develop their lab works and demonstrations. Our study supports the interpretation that in everyday school life, teachers do not have sufficient time to create individual study materials or develop hands-on equipment for students (cf. Driver and Scott 1996).

We tried to organise different kind of support for distance learning periods. In our case teachers evaluated e-mail- discussion list and chat sessions to be least significant of all the activities during the project. On the other hand teachers used possibility to ask help from their supervisor through e-mail. Therefore in further projects much more attention have to be paid on how to foster inquiry, encourage discourse and inspire collaboration during distance training period.

Based on responses it is obvious that teachers participating in this kind of in-service training project have to have the possibility to co-operate and discuss in small groups and reflect during the training. In our project, it turned out those courses where teachers produced concept maps before lectures or project plans before laboratory activities in small groups were evaluated by teachers important from the point of view of their daily work.

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FIGURE:

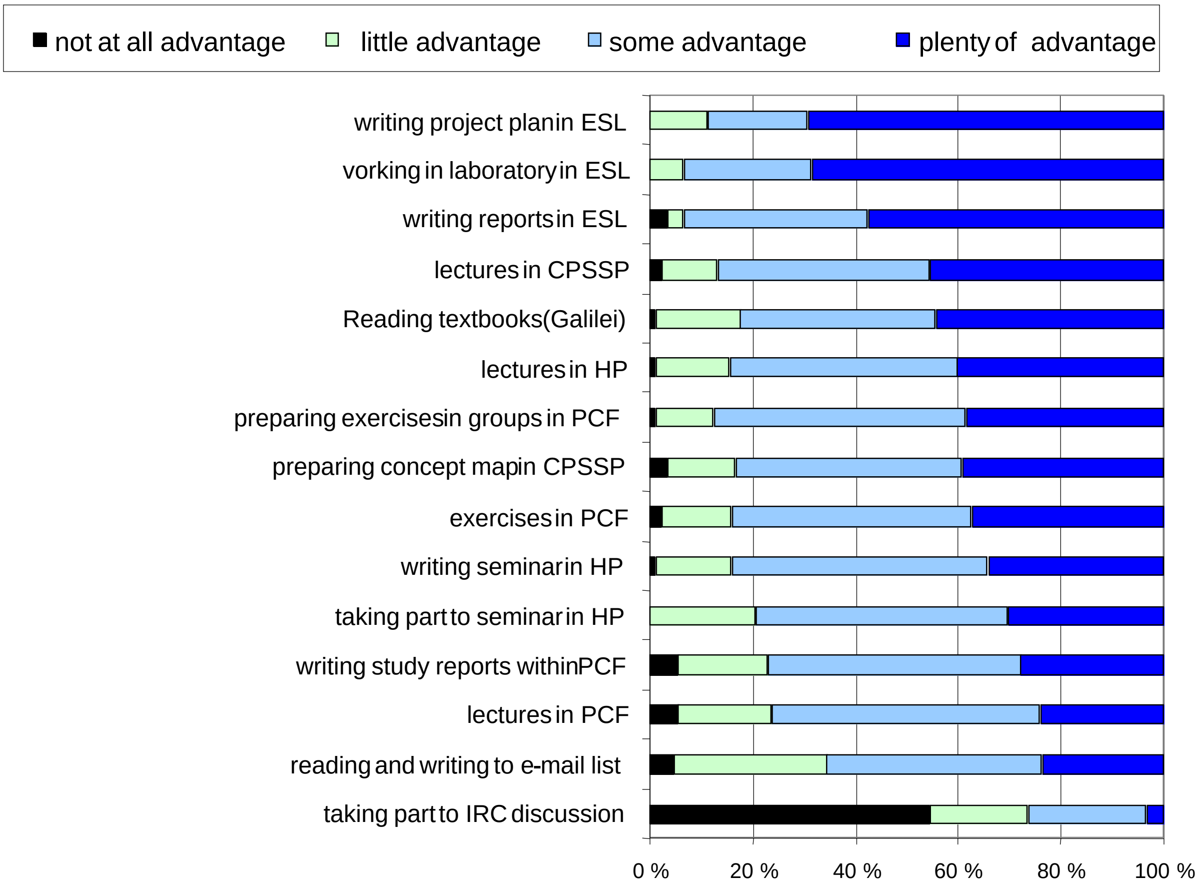

Figure 1. The teachers' opinion of the courses and approaches used at inservice training during *ITPT* -project.