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THE ROLE OF RESEARCHERS IN THE IMPLEMENTATION OF EDUCATIONAL POLICIES: THE FINNISH LUMA PROGRAMME (1996-2002) AS A CASE STUDY

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Abstract. *The Finnish LUMA Joint National Action (1996–2002) and related action, organised by the National Board of Education are introduced in general. A number of professional development projects for science teachers have been run through the Department of Applied Sciences of Education at the University of Helsinki in the context of the LUMA programme. Properties that made these projects successful are discussed and compared to previous research on how educational innovations are adopted for general use.*
Keywords: *educational policy, adoption of educational innovations, in-service training of science teachers.*

Introduction

From 1995-2003, the Finnish government made a concerted effort to raise the level of mathematical and scientific knowledge in Finland up to international standard. In 1996, the Ministry of Education announced an extensive programme (LUMA[1] Joint National Action) to be run from 1996 to 2002. The programme underwent revision in 1999 (LUMA Programme, 2004). Due to the wide-reaching scope and numerous sub-projects of the whole LUMA programme, space considerations in the current paper make it possible only to present some of the activities conducted during the programme. The discussion will focus on one of the sub-projects (referred to herein as "the LUMA project"). The LUMA project was launched by the National Board of Education in order to develop the teaching and learning of mathematics and the natural sciences. Governmental assistance within the project included the financing of new school laboratory equipment, the development of pedagogical study materials for teachers, and the organisation of long-term in-service training programs for teachers. Similar approaches to teacher professional development have been recommended by other researchers (for example, Fullan, 1991, p. 37).

The general objectives of the LUMA programme were both qualitative and quantitative. The quantitative goals were: to increase the combined intake in universities and polytechnics in the natural science and technology fields; to increase the number of candidates who chose advanced mathematics, physics, and chemistry in the high school matriculation examination; to improve gender equality; and to increase the number of mathematics and science teachers, in order to meet the needs for education at all levels and ages. The qualitative goals were: pupils and students should obtain comprehensive knowledge and skills in mathematics and natural sciences; vocational students should attain the mathematical and scientific knowledge and skills needed in different fields and occupations, and for further study; and citizens should have the opportunity to acquire the mathematical and scientific knowledge they need in everyday life. The general goals and a description of all sub- programmes in the Joint National Action can be seen in the final report of the LUMA programme (Ministry of Education, 2002). All teacher educators and researchers, teachers, people in industry and its organisations, and other school interest groups were asked to participate in the national programme on a voluntary basis.

This kind of educational policy and its method implementation of it is quite common in many countries. There is a good argument for the growing need for extensive knowledge in mathematics and natural sciences due to their important role in the high level of modern and future literacy necessary for the emerging (information) society, as well as in political and economic decision

[1] The acronym LUMA comes from Finnish language terms: Luonnontieteet [Natural Sciences] and Matematiikka [Mathematics])

making. Moreover, education in science and mathematics has a vital role in the promotion of national innovations and securing international competitiveness (Kubota, 1993; Black, & Atkin, 1996). The nature of high-technology industries calls for personnel with a solid education in science and mathematics, but also good competence in the application of these fields through different skills such as experimentation and learning skills. Furthermore, the number of pupils who opt for sciences in upper secondary school, especially for physics, is not sufficient to meet the needs of technical and scientific education in universities and polytechnics. Hence, politicians and spokesmen for industry, as well as researchers and teacher educators, took an active role in the LUMA programme with the aim to promote science, mathematics, and technology teaching and learning in Finnish schools.

There were no resources allocated directly for research in the context of the LUMA project. However, for researchers and teacher educators, there were several other reasons why it was useful to take an active role in voluntary work for the national LUMA-project. First, there was financial support available for organising long-term in-service training and school teachers were especially interested in the possibility to combine educational research with training activities. Furthermore, it was easy to deepen old relationships or build up new and innovative co-operation with high-technology industries. This was especially easy for the Department of Applied Sciences of Education at the University of Helsinki (DASE) because there were long traditions of professional teacher development programs and co-operation with the National Board of (General) Education and industry (Kuitunen & Meisalo, 1988; Kuitunen, 1996). Traditionally, it is assumed that school-industry partnership can lead to workshops or in-service training, study visits for teachers or students including work in industrial laboratories, as well as the development of new learning materials, videos, or films (Eash, 1990; Kubota, 1993). In addition to these we have been talking with teachers to identify examples of how modern information and communication technology (ICT) is used in industry.

However, the implementation of educational programmes is more difficult in practice than educational policy discourse implies. It is difficult to change teachers' habitual teaching methods, their beliefs on what is effective teaching, or the ways they use (or do not use) learning materials and laboratory equipment through the in-service training of teachers (Willis, 1997). Teachers typically use presentation-recitation teaching, and "teach subject matter" not educate students (Sarason, 1990). During the past decade, there has been much discussion of teachers' beliefs about teaching and learning as well as about the possibility of changing these beliefs through educational reforms, in-service training, or professional development programs. Tobin *et al.* (1994, 64) summarise the relationships between teachers' beliefs and reform efforts: "Many of the reform attempts of the past have ignored the role of the beliefs of teachers in sustaining the status quo. The studies ... suggest that teachers' beliefs are a critical ingredient in the factors that determine what happens in classrooms."

The main purpose of this paper is to briefly give an overview of the Finnish LUMA project. We shall present and discuss examples of projects the researchers and teacher educators at DASE organised in the context of the LUMA project. We shall then draw some conclusions about the appropriate pedagogical approaches suitable for the implementation of national educational policy, based on our experience and research results. The viewpoint is highly personal: we have been unofficially consulting civil servants during the project, but we have had no official role and this paper emphasises our own experiences.

The LUMA project

In 1995, the National Board of Education launched a project to develop the teaching of mathematics and the natural sciences (the LUMA project) as part of the government's LUMA programme. At the very beginning of the project, it was assumed that the best way to guarantee high-quality learning in science and mathematics was to have motivated, enthusiastic, and skilled teachers in primary and secondary schools. In Finland, subject teacher training[2] takes on average 5 to 6 years, and student teachers obtain the M.Sc. degree, for which they need 160 (Finnish) credits[3] minimum. Their Master's thesis is written in their major subject (e.g., physics). In practice, two main approaches were chosen for the LUMA project: 1) the organisation of in-service training in mathematics and science and the pedagogics of these, and 2) the building of teacher networks.

During the LUMA project, teachers had many opportunities for in-service training free of charge. There were opportunities for both university-level degree studies of 15 to 20 credits' value in mathematics and sciences, and for shorter studies of 3 to 5 credits aiming at an improvement in their subject knowledge and pedagogical skills.

The National Board of Education established 16 networks involving 78 local authorities and within their regions, a total of 270 educational institutions. Primary schools, lower and upper secondary schools, as well as vocational schools and institutes collaborated with each other and with other educational institutions and enterprises in their localities (see in detail NBE, 2004). The main goals of the networks were as follows:

- development of learning environments in science in order to encourage students in the observation of phenomena, the conduct of sound experiments, and the application of knowledge to solve problems in real-life situations;
- dissemination of educational innovations from network schools to local schools, and gradually throughout the country;
- use of an environmental approach in the teaching of mathematics and science;
- collaboration between mathematics and science teachers at different educational levels so that the curriculum will continue smoothly from preschool onwards;
- support for different students (girls and boys as well as students with learning and other difficulties or the most talented students) so that all students will have an equal opportunity to learn mathematics and science.

The anticipated results of changes in teaching and learning were expected to be as follows:

- students' interest in mathematics and science will increase;
- both boys and girls will choose more courses in mathematics and science subjects and study them in more depth;
- all students will be able to improve the quality of their own learning processes;
- students will acquire both knowledge for everyday life and learning for further studies;
- students will assimilate the knowledge and willingness needed for a contribution to sustainable development.

The National Board of Education and several other organisations, such as industry interest groups, produced learning material to be used by teachers. Some examples of the learning material include a manual on school laboratories and facilities in science teaching, a book to assist physics teaching in primary schools, and a publication dealing with experiments and modelling in science for both lower and upper secondary schools.

During the course of the LUMA programme, various parties invested considerable intellectual and material resources in it. The Ministry of Education and National Board of Education assigned a total of 34 million euros in development funds to the Joint National Action LUMA. Mathematics and science teachers' in-service training was one of the most visible outcomes of the LUMA programme; altogether, 9.4 million euros were allocated in the State Budget for in-service training

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2 Physics and chemistry teachers teach physics and chemistry at grade levels 7 - 9 (pupils 12 - 15 years old) in upper grades of the comprehensive school and at grade levels 10 - 12 (students 15 - 18 years old) in upper secondary school. In Finland, they are called "subject teachers".

3 1 credit in Finland means one week of full-time study. One Finnish credit is worth about 1.5 to 2 ECTS credits. The credit system is now under revision and will be changed to be in accordance with the European system.

programmes and the municipalities were expected to use an equal amount of resources. Approximately 11,000 teachers took part in the training organised under the supervision of the National Board of Education, and their efforts yielded some 85,000 study credits. Government subsidies for equipment acquisition in pilot upper secondary schools totalled 1.7 million euros. Industry also contributed substantially: Nokia alone provided 1.38 million euros for the same purposes, and a number of other companies contributed substantial sums (Ministry of Education, 2002).

An international evaluation report on the LUMA programme (Allen, Black, & Wallin, 2002) identified many successes. The report showed that co-operation between teachers increased, and connections with partners outside schools have become stronger than ever before. Experimental learning has increased, and many schools now have classes or streams that specialise in mathematics and science. Teachers eagerly participated in the in-service training, and many have taken degrees, improved their subject knowledge and widened their pedagogical skills. The public appreciation of the value of mathematics and science has increased, and the teachers have simultaneously placed a higher value on their profession. However, the implementation of the whole process was judged diffuse and uncoordinated, and there were no guarantees built into the process to ensure that new ideas would spread outside the networks established by the National Board of Education.

Activities of DASE in the context of the LUMA project

Research and development work at the Department of Applied Sciences of Education at the University of Helsinki (DASE) has been organised in several research centres. The Research Centre for Mathematics and Science Education[4] (RCMSE) conducts research in several areas related to science and technology education and in-service and pre-service training. Several qualitative goals of the LUMA programme fit in well with the goals of research into teachers' professional development (PD) projects or in-service training during the years 1996 – 2002 and, therefore, it was appropriate to look for co-operation, and even to connect these research-oriented PD-projects to the LUMA programme. Professional development is here defined as continuous inquiry regarding practice, which is facilitated by researchers or in-service trainers (university staff members), and the main aim is to accept educational innovations, like effective ICT use, new teaching or learning methods, or new learning materials (Lieberman & Miller 1992, 106).

When planning the research activities connected to PD-projects, we followed what Fullan (1991, 68) wrote about the acceptance process of educational innovations and properties of the programs that have an effect on their final acceptance. Fullan (1991, 68) categorises the properties of educational innovations that affect their acceptance in three classes:

1. The properties of the innovation or new ideas. For example, how demonstrations or ICT should be used in science education. It can be expected that if an innovation is too complicated for beginners, it is not accepted.

2. Local characteristics. For example, the pedagogical orientation of the teachers and their beliefs about the usability of an educational innovation, administrative leadership and support. The design of learning materials should support acceptance.

3. External factors. For example, the national strategy and framework curriculum, funding available, nature of training, and co-operative partnerships with outside organisations, all have an effect on the adoption of an educational innovation. Different kinds of networking may foster the adoption process, such as co-operation between (i) schools, (ii) teaching and research or (iii) co-operation between schools and their environment or working life. In addition, people are naturally resistant to new ideas or innovations.

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[4] see more: http://www.edu.helsinki.fi/malu/tutkimus/index.en.htm

Altogether, we organised three large PD-projects and 12 long-term (3 to 5 credits) in-service training courses as well as several short workshops for science and technology teachers in the framework of the LUMA programme. Later in this paper, long-term activities will be abbreviated as PD-projects. Within these projects, science teachers had the possibility to *co-operate* and discuss issues in small groups, share their experiences, *reflect* on their present teaching practices, plan new teaching sequences and organise small teaching experiments in their classrooms, evaluate their activities, solve problems creatively and co-operatively, and attempt to improve the nature of their approach to teaching science and widen their understanding about the learning of science. We use the term "co-operation" to describe social interaction in small groups where teachers (or students at school) talk and share their cognitive resources and work together to solve a problem or complete a task. When teachers reflect in small groups, they inspect, evaluate, and share their previous experiences and knowledge about science education and learn from experience (Eraut, 1994). Training and working in the projects was *contextual*, or connected to real teaching and learning situations at school. Contextuality as an approach also appears in our PD-projects through different kinds of visits, like a visit to a factory or other place of work. These visits were included in the PD-projects to demonstrate the relevance of science education to everyday life and to promote an understanding of normal working life. By these means, it was easier for teachers and us to develop new learning environments for science education so that they correspond to future operational environments, or environments in modern working life.

On the basis of collected feedback during the PD-projects and of the self-evaluation data on what the teachers thought they learned during the project, we are sure that co-operation and reflection were important properties of the projects. Otherwise it was difficult to recognise and change the established practices. Moreover, various kinds of learning methods during the courses, such as co-operative learning, group discussion and, project work were actively used and they were appreciated by the teachers.

All of our PD-projects during the years 1996 – 2002 were research-oriented, and several of the publications connected to the projects are mentioned in the text below. Research enquiries related to these projects included questions about the nature of social interaction and models of learning used in the training, as well as the usability of the learning materials designed within the projects. We also developed the use of ICT in science education and designed teachers' materials, such as guidebooks, demonstration equipment, and computer programs, and also evaluated how well these materials were accepted and their usability.

The Finnish Virtual School for Science Education (*FVSSE*) (1999 - 2003) (see more Lavonen, Meisalo, Aksela, & Juuti, 2001) was founded together with seven local authorities throughout Finland (who also partly financed the project) and researchers from DASE. The goal of *FVSSE* was to improve the use of ICT in science education. Two-day contact meetings twice a term, and computer conferences between the meetings, were selected as the main working models for *FVSSE*. Typical in this professional development project was co-operation, reflection, contextuality, and the planning of small teaching experiments together. An industry visit was included in all 13 contact meetings. Self-evaluation data showed that the 25 participating teachers integrated ICT in several ways into the science education they planned. Moreover, the teachers' ICT competence increased.

The Get Electronics Project, GEP (1994-2002) (see more Lavonen & Meisalo, 2000; 2002) aimed to support teachers of physics and technology (120 altogether) in planning and delivering instruction on the basics of electronics and electricity, and to prepare learning materials, including a kit for experimenting with electricity and electronics. A survey of teacher and student opinions revealed that the majority felt the textbook had a high level of readability, clarity, intelligibility, and interest, and that the kit was versatile and easy to use. The results of the survey also showed that the teachers were active in developing and improving their teaching. The support of teachers' organisations and industry was important for this project and the results could be partly utilised in the designing of other activities related to *LUMA*.

The project *LUONTI* (1995 – 2002) (see more Lavonen, Aksela, Juuti, & Meisalo, 2003) was founded in autumn 1995 with the aim of creating learning environments where *ICT* can be used in a flexible way and to conduct educational research focusing on learning in these environments. Actually, *LUONTI* started before *LUMA,* but both projects benefited from close co-operation. During *LUONTI*, a Microcomputer Based Laboratory (MBL) package for school laboratories and teachers' guides were developed in consultation with a group of science teachers. Afterwards, we surveyed how science teachers experienced the new MBL package, and re-designed the existing package based on teacher evaluations. A web-based MBL guide was also developed from in-service teacher needs (Juuti, Lavonen, & Meisalo, 2003). This project also produced a doctoral dissertation (Lavonen, 1996).

The Nordic Council of Ministers initiated the NORDLAB project to promote mathematics and science teaching in all Nordic countries. Each country specialised in a specific topic. The Finnish contribution was on the promotion of new technology in science teaching. Grants were used to develop materials for use over the Internet, especially for the in-service training of science teachers (e.g., Juuti, Lavonen, & Meisalo, 2003). This material was also available to the course arranger of LUMA. Here a full time researcher was able to start his doctoral work.

Discussion

Previous research has demonstrated that it is difficult to change the beliefs of science teachers about teaching and learning and their usual teaching habits (Sarason, 1990). Therefore, we carefully followed Fullan's (1991, 68) list of the properties of educational innovations that affect their acceptance or rejection. All three of Fullan's categories had a positive effect on the results of our PD-projects.

An external factor, LUMA Joint National Action, established a positive atmosphere for PD-projects, and ensured that funding was available for such items as new laboratory equipments and PD-projects. In addition, independent private organisations, such as those involved in high-technology industries, had a positive attitude on co-operation with schools. Different kinds of LUMA networking fostered the adoption process of educational innovations.

We made the educational innovations (e.g., the use of ICT in science education, new ways of teaching about electricity) easily adaptable by developing different kinds of learning materials. We were well aware of the variability between different teachers' pedagogical orientation and their beliefs about the usability of educational innovations, and we were therefore able to design the pedagogical properties of the pedagogical activities used in the PD-projects to be effective. On the basis of research conducted in the projects and our own experience, we suggest that first of all, the project should be of sufficient length. We also conclude that the following items must be considered, whether the aim is to design effective educational innovations and help teachers adopt these innovations, or just increase science teachers' competence in science education.

The strength of the LUMA project seems to be its success in attracting teachers and researchers to join the common effort for advancing mathematics and science teaching. Quite a large number of teachers and researchers worked voluntarily or on nominal pay. Resources were collected from several sources for experimenting, designing novel learning materials etc. Other on-going research and development projects were aligned to support the goals of LUMA. The participating schools and teachers obviously benefited substantially. On the other hand, there were also weaknesses. Little emphasis was put on the spread of the new approaches to teaching to the majority of Finnish schools. It is likely that the process is continuing now, but much time has been wasted already.

The role of researchers was by no means central in the LUMA project. However, much research-oriented development work has been connected with it and it has resulted in a useful exchange of information between researchers and teachers from different parts of the country. Many doctoral students had good opportunities to obtain valuable research data. A more detailed study could reveal further interesting aspects of the role of research in the success of this project.

Conclusions and Implications

Based on the official LUMA evaluation and our experiences in the PD-projects, some conclusions may be drawn. It is important that enough time be allocated for *co-planning the whole project and each phase of the project*. Teachers' beliefs, current practices (teaching or learning methods used), and open questions should be identified and discussed during the goal-setting process of the PD-project. Meetings or training situations should be designed together with the teachers and organised in interesting places, such as factories or other places of work where principles can be demonstrated in a practical way. Moreover, the project itself should be run long-term.

PD-projects should include small group activities for teachers, like the planning and evaluation of small teaching experiments (teaching sequences), which are supported by lectures and demonstrations. Support material and teacher reports should be published for easy access, such as on web pages (Joyce & Showers, 1995). The teachers should be guided *to co-operation and reflection in small groups.* The teachers must have the chance to practise new approaches, models of teaching, and so on in their own work, as well as write about and discuss their experiences with their own students. It is necessary to use a variety of pedagogical approaches due to the fact that teachers tend to teach as they have been taught. The teachers must believe that they can learn from each other. This personal reflection should be facilitated by a supervisor or trainer (Moonen & Voogt, 1998). Such approaches are also recommended by Rogers (1995, 281 - 334). He emphasises the influence of interpersonal networks on an individual's adoption process.

Contextuality within a PD-project should be made concrete. One way to do this would be to guide teachers to different development projects, including teaching experiments, instead of formal in-service training with lectures and formal exercises. This classroom implementation can be supported through web pages or ready-made learning materials. This kind of support material has shown its value when teachers organise teaching experiments in their schools (Moonen & Voogt, 1998). Educational innovations should also be discussed in different contexts. For example, ICT use in science education should be discussed through integration with teaching and learning methods (e.g., practical work, learning by reading and writing, and working in a small group) and to different interesting contents (e.g., structure of matter or energy resources) and contexts (e.g., science in society, technological context, human-being context). A visit to a factory is one appropriate context where the relevance of science education can be discussed.

PD-projects should contain *effective teacher networking* that consists of an appropriate combination of face-to-face contact meetings and virtual meetings (computer conferences or discussions in newsgroups), and an appropriate group size should be established. Research shows there should be about two to four teachers from the same school and altogether about 15 to 25 teachers teaching the same subjects. (Joyce & Showers, 1995; Moonen & Voogt, 1998).

Uncertainty should be considered *as a resource for creativity* in PD-projects. New ideas or innovations in science education and lack of information on possible new ideas mean uncertainty. This uncertainty increases the number of possible alternatives to the development of innovations. Therefore, there has to be room for free ideation in an open environment, positive feedback directed to all ideas, and an understanding of the nature of creative problem-solving processes. Open environments also help teachers to take risks and allow failure in teaching experiments. (Rogers, 1995, 5-6).

PD projects should reflect "real-life" application situations. The professional development programs of teachers should correspond to their future operational environment or the environment in modern working life and, therefore, visits to places of industry visits and other relevant locations should be included in development programmes, with the aim of familiarisation with working life.

On-line evaluation and discussions with teachers about evaluation data is important. Evaluation data should be collected continuously by questionnaires, interviews, observations, teacher self-evaluations, and project reports, in order to follow how participating teachers have adopted educational innovations. All face-to-face contact and virtual meetings should be evaluated together, and new goals set based on this evaluation.

Enough resources must be allocated for teachers' work, co-operation, travel, and equipment. Resources should be allocated directly to schools for travelling expenses and development work such as equipment, software, projection devices, and access to the Internet (Czerniak et al., 1999).

The *dissemination and exploitation* of the resultant knowledge should be planned in the early stages. Local training sessions and workshops, training sessions in national conferences and workshops, article series in teaching journals, and so on, should all be agreed in good time. It is an advantage if participating teachers come from different parts of the country.

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Резюме

РОЛЬ ИССЛЕДОВАТЕЛЕЙ В РЕАЛИЗАЦИИ ОБРАЗОВАТЕЛЬНЫХ ПРОГРАММ: ПРОГРАММА LUMA В ФИНЛЯНДИИ (1996-2002)

Яри Лавонен, Веийо Мейсало, Калле Юути

В течении 6 лет (1996-2002), Финский Национальный совет по образованию проводил совместный проект LUMA (Проект по естественным наукам и математике), чтобы собрать вместе учителей, школы, университеты, людей из промышленности и другие заинтересованные группы с целью поднять уровень знаний в естественных науках и математике до международного уровня. Главное ударение было сделано на запуск программ профессионального развития учителей (ПП), на улучшение школьных лабораторий, а также на разработку и развитие новых инструкций.

Статья описывает LUMA и рассматривает усилия, приложенные во время исследования персоналом Департамента Прикладных естественных наук в образовании при Университете Хельсинки. В соответствии с исследованием наиболее эффективны программы ПП которые: нацелены на обеспечение активного вовлечения учителей, предлагают подготовку во время работы, предоставляют полные материалы инструкций и оборудование, разработанное в сотрудничестве с учителями, и создание разнообразных каналов коммуникации учителей и обмена опытом.

Цель успешной программы ПП – увеличить профессиональную независимость учителей.

Ключевые слова: политика образования, адаптация инноваций, повышение квалификации учителей естетсвознания

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