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Networking School Teachers to Promote Better Practice in the Teaching of Science across Europe

SUZANNE GATT & MANUEL FILIPE PEREIRA CUNHA MARTINS COSTA

Introduction

Teachers in schools are facing many challenges in the current fast-changing world, and even more so now during a recession, as funds for educational resources are shrinking. But they are experiencing a constant need to update their teaching practice and implement new approaches to promote better performance by their students. These demands reflect educators' responsibility to help students be better prepared for the challenges of an insecure future world and labour market. Science teachers in particular are central to help to achieve the targets set in the Lisbon Strategy to make the European Union 'the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010' (http://www.europarl.eu.int/summits/lis1_en.htm). The Lisbon Strategy not only called for reforms and presented challenges to higher education with the Bologna Process (European Ministers of Education, 1999) and to vocational education with the Copenhagen Process (http://ec.europa.eu/education/copenhagen/copenahagen_declaration_en.pdf). It is also having an impact on the provision of compulsory school education, as can be seen in the Education and Training 2010 programme of the European Commission, which emphasises the acquisition of key competences, with science being one of these.

Teachers in both primary and secondary schools face the challenge by the current education systems to improve their practice by devising new and more effective methodologies (Darling-Hammond & McLaughlin, 1995). Since they are mainly confined to their classroom, involved in their daily business of teaching a group of children under their responsibility, they have very few opportunities for professional development. Primary teachers in particular need to be in the classroom the whole working day. Although secondary teachers enjoy short periods of 'free' time, it is often spent in the school staff room correcting students' work. The time for in-service training thus becomes limited and is often not ongoing. As a result, teachers are easily isolated and bound to the confines of their classroom and their school. They have very few opportunities to share their professional lives with other professionals in education. As technological educational resources and the knowledge that researchers are generating about effective teaching methodologies grow, the demand for teachers to keep abreast of developments in their area and to work at adapting and improving their teaching becomes greater. In addition, teachers do not have access to other teachers' examples of good practice. This creates, to a certain degree, a barrier to their professional growth. Teachers need to be active in communities of practice or learning communities where they can learn about new educational theories and approaches, as well as develop professionally. With the current state of affairs in many school systems in Europe, keeping teachers confined to their single school experience can have serious repercussions on their impact in the classroom and on the education system overall.

This article deals with how there is recognition of the problem of outdated and boring traditional teaching in schools across Europe (Rocard *et al.*, 2007). The main cause is the way in which teachers and schools present and engage students in science. In trying to find ways to rise to this challenge of providing a better quality science education, an argument is put forward in favour of networking as a way of promoting teachers' professional development. The Comenius 3 project Hands on Science, funded within the Socrates Programme of the European Commission from 2003 to 2006 — but which is still active and ongoing today — is described as an example of good practice in promoting networking among science teachers.

The Main Problems with the Uptake of Science by Students and the Challenges to Science Education

The EU is making overall progress, with particularly strong increases in the number of graduates in science, engineering, social sciences and humanities, both at first degree and at graduate level (European Commission, 2009). Since 2000, the EU-27 share of researchers in the labour force has also grown by 1.9 % per annum on average, which is twice as fast as in the US and at the same rate as Japan (European Commission, 2008). This can be considered as an improvement over the declining number of science and technology graduates across Europe reported by the European Commission (2004) a few years earlier. Although a key study by OECD (2006) showed how the number of students graduating in science and technology and the number of PhDs were decreasing in many European countries and beyond, more recent statistics have been more positive. The EU has had more tertiary graduates and doctoral graduates than the US and Japan since 2000. For example, in 2005, 100,000 doctoral degrees were awarded in EU-27, compared to 53,000 in the US and 15,000 in Japan (European Commission, 2008). The Nordic countries have, in general, achieved the highest growth rates for graduates, science and technology professionals, and R & D personnel and researchers (European Commission, 2008). The main increases in science graduates were in Portugal, Poland, The Netherlands, Romania, Hungary, Slovakia and Cyprus. In engineering, the increase was registered in Romania, Slovakia, and the Czech Republic. However, on average, the EU still has proportionately significantly fewer researchers than the US and Japan. In 2006, the number of full-time equivalent researchers per thousand in the labour force was 5.6 in EU-27 compared to 10.7 in Japan and 9.3 in the US (European Commission, 2008). The challenge for more students taking up science and engineering thus still persists.

An insight into students' level of performance in science across different countries can be obtained from international studies such as Timms and PISA. PISA 2003 identified Finland as first in the ranking order for science, even though performance was not statistically significantly different from results obtained by Japan, Korea and Hong Kong. The countries that obtained higher than OECD average performance included Australia, Belgium, Sweden, Switzerland, Liechtenstein and Macao-China. Countries that did not differ from the OECD average were Germany, Hungary, Poland and the Slovak Republic (OECD, 2004). The worst performing countries were mainly among the poorest, even though countries like Denmark, Greece and Luxembourg were also included in these.

Gender differences have also been reported for performance in science, even if the gap is narrowing. PISA 2000 showed the smallest differences among all content areas in science, with an OECD average difference between males and females of six points in favour of males. On the other hand, a gender difference in favour of females who performed better was found in the cases of Finland, Iceland and Tunisia (OECD, 2004). In PISA 2003, the researchers concluded that there was no clear pattern for gender differences and that any differences were very small. This was considered as an encouraging sign, as it seems that ground is being gained by girls, at least with respect to performance, even if this may as yet not be reflected in the percentage opting for a career in science.

Although the importance of the sciences is recognised by the public, government, industry and even young people themselves, one finds that in countries like the UK, there is still a persistent decrease in the popularity of chemistry and physics, despite an increase in the overall number of students furthering their studies beyond compulsory education (Royal Society, 2006). This concern was also highlighted in the Rochard Report (European Commission, 2007) commissioned by the European Commission, which tackled the issue of how, in recent years, many studies have highlighted an alarming decline in young people's interest for key science studies and mathematics. This report argues how education systems across Europe have the problem of maintaining a constant supply of scientists for research and industry by attracting more students to choose science subjects as specialisations.

The drop in the provision of scientists is the result of other problems inherent to the type of science education being provided in schools across Europe. The main problem arises from a situation where, historically, science had been only for those students who wanted to pursue a scientific career, while there is now agreement that an education in science is important for all school students. However, despite this recognition, science curricula have simply evolved from pre-existing forms and still reflect science's old traditional role in secondary schools with the foundational knowledge of the three sciences — Biology, Chemistry and Physics. This problem is articulated by Osborne and Dillon (2008) who reflect the views of the main science educators across Europe. The argument they put forward is that science education provision in schools does not seem to meet the needs of the majority of students, as it does not provide a broad overview of the major ideas in science. Nor does it provide insight into how reliable knowledge is produced or the limits of certainty within which scientists work. Hence, both the content and pedagogy in most of the current science classrooms in Europe are increasingly failing to actively engage young people enough to attract them to continue their studies in the area. This is reflected in a strong negative correlation between students' interest in science and their achievement in science tests (Osborne & Dillon, 2008).

There is also the problem that students show little interest in science, particularly at secondary level of education where a significant drop from earlier years has been documented. The ROSE (Relevance of Science Education) project includes research about students' interest in science in more than 40 countries. Results show how their interest in choosing a science career is related to the country's level of development. Students in developed countries were found to be much less interested than those in developing countries. This trend was observed, despite young persons stating a positive view of science. Only, the problem is that they do not wish to be part of science (Sjoberg & Schreiner, 2005).

Professional Development for Science Teachers

All these problems related to the provision of science education pose great challenges to school teachers who are in the front line of action with students. They need to discard their traditional practices and take up more innovative and effective methodologies such as the Inquiry-based approach (European Commission, 2004). Continuous professional development (CPD) is one of the best and most effective ways of achieving teacher development. In experiencing an era of reform, teachers need be provided with opportunities to share what they know and are capable of achieving; discuss what they want to learn as professionals; and be given the chance to connect new concepts and strategies to their own unique contexts (Darling-Hammond & McLaughlin, 1995).

Teachers play a central role in the success of innovative projects promoting better student performance (Hawley & Rosenholtz, 1984). This makes their professional development crucial to achieving changes and improvement in the teaching of science. Supovitz & Turner (2000) identify six dimensions of what they label as 'high qualify professional development'. These include: the need to immerse participants in inquiry, questioning and experimentation; the need for training to be intensive and sustained; opportunities to engage teachers in concrete teaching tasks, based on their experiences with students; focus on subject-matter knowledge and deepen teachers' content skills; be grounded in a common set of professional development standards, as well as student standards; and be connected to other aspects of school change. Professional development can be considered to be of high quality if it includes a number of these six aspects. Guskey (2003) also identifies the need for Continuous Professional Development (CDP) to enhance teachers' content and pedagogical knowledge; provide adequate time and resources; promote collegial and collaborative professional exchange among teachers; give the chance to teachers to evaluate their CPD experience; and include site-related in-service training. Loucks-Horsley *et al.* (2003) added the dimensions of a well-defined image of classroom learning and teaching; training based on research and treating teachers as adult learners; as well as providing opportunities for teachers to take on leadership roles in their schools and districts. Networks and networking have great potential for solving structural problems in education (Bienzle *et al.*, 2007), as they include a number of the dimensions for professional development mentioned above.

Networking among science teachers was promoted and recommended by the European Commission Report on Science Education (European Commission, 2007). The Rochard report (European Commission, 2007) argues that teachers are key players in the renewal of science education and that being part of a network provides them with opportunities to improve the quality of their teaching and supports their motivation. Networks are considered to have the potential to be an effective component of their professional development. Since teachers are often confined to their classrooms with short 'free' periods, networks can enrich their classroom practice. Networks promote cooperation within and between schools, collaborative reflection, development and evaluation of instruction, exchange of ideas, materials and experiences, quality development, cooperation between teachers and researchers and support and stimulation from research. Hence, they can complement the more traditional forms of teacher in-service training (European Commission, 2007). One of the recommendations made by the Rochard report is that improvements in science education can be brought about, amongst other actions, through the development of teachers' networks. District and national organisations can play a crucial role in providing a formal platform for examining practice (Darling-Hammond & McLaughlin, 1995).

Teachers need to feel part of a community which values their contribution to the subject and provides them with opportunities for continual professional development (Institute of Physics, n.d.). An important aspect is the opportunity to discuss ideas and ask for help from teachers in other schools. One example is the Physics Teacher Network initiative by the Institute of Physics in Great Britain and Ireland which was established to provide support for Physics teachers by Physics teachers. As many as 2,800 teachers are members of the network. This is one example of how professional organisations can provide informal 'critical friends', allowing for collaborative work on real issues and the chance to work with teachers from other schools (Darling-Hammond & McLaughlin, 1995). Examples from the US include the National Writing Project and an analogous set of professional development initiatives in mathematics (Darling-Hammond, 1999). Research by Schlager *et al.* (2002) has also shown how online-networks can create a community of practice which is central to teacher professional development. Getting teachers together in networks for informal retreats and other evening meetings have also been found to help build professional relationships and help new members to feel part of the group (Liebermann, 1996).

It is important to understand what networks are and how they work in order to fully conceive the contribution they bring to professional development. The term 'network' was coined in the natural sciences. It reflects the metaphorical meaning of a system of interconnections that is similar to what one finds in railway and road networks (Bienzle *et al.*, 2007). This same metaphor is widely used in Information and Communication Technologies like the Internet. Teachers' networks are different from Internet networks, as they are a form of networks involving social ties between actors, persons or organisations. Networks in education usually involve cooperation between a number of professionals and/or organisations over time to attain a specific goal and/or work collaboratively towards the same objectives. They are regulated by a sense of mutual trust and professional respect, resulting in experts sharing and making technical knowledge available to one another for the benefit of all. Thus, networks promote the transfer of know-how, leading to the professional development of their members.

Bruun *et al.* (2005) identified three common forms of knowledge networking: modular, translational and pioneer. Modular knowledge networking involves individuals, groups, or units, representing a number of separate knowledge regimes, who interact through clearly-defined separate knowledge-based contributions that are coordinated by an overall coordinator. Translational knowledge networking also consists of individuals, groups, or units embodying different knowledge frameworks, but different parties can interact with each other in generating and sharing knowledge. Learning and knowledge generation in such a network involve different levels: local practice, as well as global interfacing. Pioneer knowledge networking includes interaction across the network, with the original knowledge frameworks playing a less significant role. This is the least structured and most fluid of the three types of networking, as it places high expectations on exploration and discovery. Due to its open-methodology, there is usually no single coordinator, but a number of project managers who ensure that communication across the network is maintained at the highest possible standard and that participants receive the support they require to facilitate their interactions (Bruun *et al.*, 2005).

The Internet is one powerful tool to promote certain types of networking. It can provide educators with opportunities for networking with colleagues, learning about new developments and establishing a sense of community among teachers without the need for physical mobility. Abu Bakar *et al* (2006) identified different forms of Internet networking: E-Journals, allowing teachers to view and add information regarding online journals available for free on the Internet; E-Thesis, allowing pre-service and in-service teachers to view and add abstracts of undergraduate and postgraduate theses related to Science, Mathematics and IT teaching and learning; Upcoming Conference, providing the option to view and add information regarding upcoming conferences; Links Directory, where teachers view and add information regarding Internet links (web sites) related to Science, Mathematics and IT teaching and learning. Lesson Plans/Tips, where teachers can view and add lesson plans on teaching the various subjects; as well as Forum, involving an electronic discussion board that can be used to exchange views on topics of similar interest (p. 21).

The Examples of the Hands on Science (Hi-Sci) Project

European networks in education, like all other social networks, are structures for interaction and cooperation between individual actors (Bienzle *et al.*, 2007). The Comenius 3 network, Hands on Science (http://www.hsci.info), is an example of a network which aims to bring together schools and teachers to improve science in schools by promoting the use of more hands on science activities.

Comenius Networks were part of the SOCRATES programme (funded by the European Commission) in the field of education. Their main goal was to create links between projects carried out by school partnerships (under the Comenius 1 programme) and those relating to the training of school education staff (Comenius 2). Networks would thus coordinate and bring together projects under a similar theme so that combined outcomes could be achieved.

Proposed Comenius Networks were to be based on specific subjects of common interest to the applicants, but often pre-determined by the call for proposals which reflected priority areas for action in education identified by the European Commission. Their general aim was to promote European cooperation and innovation in school education. Networks were expected to provide a platform to assist teachers and educational institutions involved in Comenius projects to strengthen their co-operation and enable them to maintain it beyond the period of Community financial support.

Comenius 3 Networks within the Socrates programme required the participation of at least six countries and, as far as possible, different types of players in education, such as schools, training institutions, research centres, educational authorities, associations, companies etc, which were also currently taking part in projects, initiating projects or had completed projects under Comenius 1 or 2 or both.

At its beginning in 2003, when applying for funding, the Hands on Science (Hi-Sci) network consisted of 28 institutions in ten European countries (Belgium, Cyprus, Germany, Spain, Greece, Malta, Portugal, Romania, Slovakia, United Kingdom), as well as a previously established transnational consortium Conceptual Learning of Science (CoLoS). Its main goal was and still remains to promote practical work and experiments in the teaching of science to improve in-school scientific education and thus lead to a good level of science literacy in society across Europe. This demanded that the network try and reach as many teachers as possible and disseminate examples of good practice, offer training courses and provide a platform for teachers to share practice. The Hi-Sci network thus had a broad remit, aiming to promote and disseminate well-established and newly investigated practices of hands-on teaching of science in all its disciplines among school teachers, schools, and national and transnational educational boards. It still aims to achieve this by fostering the professional development of teachers and collating and training teachers in the use of hands-on experiments in the classroom. The network strives to promote a science education where students 'do' science rather than merely be 'exposed' to it. Its main aims include:

- continuously collecting and summing up knowledge, information, materials, ideas, curricula and experiences from past and ongoing Socrates (Comenius and others) projects in related fields. This involved building a database of resources on the network's website, but also organising teacher-training courses mainly for teachers applying for Comenius 2 funding;
- collecting and monitoring results and expertise achieved in former and on-going pedagogic research projects in Europe and abroad in hands-on learning at schools in the various scientific fields. This was achieved through thematic seminars, but also by bringing teachers together in the yearly international conferences;
- discussing and developing theoretical perspectives and practical approaches that are sensitive to the diversity of backgrounds. This was reflected in the thematic seminars which focused on issues such as gender, scientific literacy and new EU Member States;
- inducing the preparation and presentation of a variety of COMENIUS 1 and 2, MINERVA and other projects (at national and multinational level) involving members of the network and other players in science education. Each international conference also acted as a contact seminar where teachers were helped by the Hands On Science national coordinators to network and to work on new Comenius 1 and 2 project proposals;
- promoting better ways of using hands-on learning in school at the different levels of compulsory education. This was achieved in different ways, but mainly through the presentations at the international conferences, teacher-training courses and thematic seminars;
- inducing an interdisciplinary integrated approach to science learning through the use of experimentation. An effort was made to bring state-of-the-art pedagogies to teachers attending the Hands on Science International Conference through a good selection of Keynote speakers, as well as by giving practising teachers the chance to share their practice with other teachers;

- promoting discussion and exchange of ideas and experiences among the different participants in the network, but particularly among teachers who are in direct contact with science students. This was mainly achieved with the international conferences, thematic seminars and training courses;
- discussing and promoting the issue of science literacy for citizenship and lifelong learning across the European Union. One thematic seminar focused on scientific literacy and lifelong learning and another on active citizenship and lifelong learning;
- creating an open web-based network, a privileged forum for sharing ideas and disseminating the networks' results and outcomes. All the presentations and materials collected during the project cycle are open-access on the project website and allow sharing of ideas beyond the direct content of the conferences and seminars which are organised;
- promoting exchange visits of schoolteachers and project coordinators between institutions in different countries by helping teachers to identify and apply for funding. Since the teacher-training courses organised by the network were funded under Comenius 2, the groups tended to be international and promoted learning about different systems, as well as being provided with opportunities to visit educational systems in other EU countries;
- organising international conferences and thematic workshops related to the use of science experiments and hands on activities in science. There was one International Conference and one thematic workshop each year of the project, with annual international conferences being organised up to this year;
- promoting and delivering training courses for school teachers and educators in different languages and countries. These were the Comenius 2 teacher-training courses which teachers could apply for from their EU National Agencies; and
- contributing to the access of women to science by promoting discussion on the issue. One thematic workshop tackled the gender perspective directly.

The network was built on the concept of a number of members acting as national contact points, one for each partner country. This allowed the coordinator (from the University of Minho, Portugal) to put together a manageable steering committee for the network, which at the same time would ensure a larger outreach of contacts and schools. The national coordinators were thus chosen to be key people in their countries, with existing contacts and already established networks of local schools. The national coordinators included people in Faculties of Education involved in teacher-training and having contacts with schools; science academics who had already been involved in promoting science through fairs and local school networks; and personnel in the local educational system of the country who also have contacts and access to schools. The network thus worked like a web at different levels: from the coordinator, to the steering committee, to the schools and teachers in schools.

The Hands on Science network used different strategies and activities to reach teachers and to expose and convince them to use a more 'hands on' approach. These activities varied and targeted different groups, but all promoted various aspects of teachers' professional development. These different activities, which have amounted to some 50 initiatives over the past five years, include:

- ***A system of associated partners to network:*** The network was directed by one main coordinator and a steering committee. There was one representative of each financed partner in the steering committee. Although a work plan had already been developed for the network's funded lifetime, the steering committee met once to twice a year to discuss its initiatives and achievements and to plan the best way to implement future activities. In addition, the steering committee members were also the national Hands on Science coordinators. They were responsible for disseminating the network's activities to schools and teachers at a local level. They also had to encourage schools and other key educational players to become associated partners of the network. One indicator of a network's success is its number of members and participants in its activities. The growing number of science teachers, educators, science teacher-trainers and science education researchers participating and contributing to the network are the result of the local networking carried out by each of the national Hands on Science coordinators. The number of official schools grew to over 40, but many more were also unofficially reached, as teachers from different parts of Europe participated in the network's activities. The total number of teachers involved in some way or another in the Hands on Science network was over 3,000 (2,000 until the end of 2006 and another 1,000 afterwards);
- ***Thematic seminars:*** One of the regular network activities was an annual thematic seminar organised by one of the partner countries. The aim was to provide opportunities for teachers and science educators to discuss specific topics that were relevant to science education. The three themes targeted during the network's funded lifetime were: the access of women to science, held in Cologne, Germany; challenges of the EU enlargement for science literacy and development, held in St. Julians, Malta; and science literacy and lifelong learning, held in Bucharest, Romania. These thematic networks provided opportunities for focused discussions on the particular aspects identified in order to raise awareness about the problems stemming from these issues and create a forum to discuss the possible way forward in tackling the challenges being faced. The participants in these activities were key stakeholders, some 50 being high officials from Ministries and academics, as well as teachers from different parts of Europe;
- ***Annual International Conferences for teachers***: The network also organised one large annual international conference. These conferences were mainly targeted at teachers and acted as platforms where teachers could disseminate examples of good practice and share ideas which they had implemented at their school with other school teachers from across Europe. Three main conferences were organised during the funding period: in Slovenia, in Crete and in Portugal. The network has continued to organise these conferences after its funding lifetime and is now at its 6th edition, which will be held in October 2009 at Ahmedabad, India. Their effect was evident in the number of participants and presentations from year to year, which grew from around 140 participants for the first Hands on International Conference, to 200 in the second, and some 400 in the 3rd conference in the final year of the project. The conference organised in 2007 in the Azores was attended by 120 participants and the 2008 conference in Recife Brazil totalled nearly 350. The network also streamed the presentations

online, which allowed for access to a much larger audience of teachers. The conferences not only allowed teachers to share their experiences, but also acted as a platform to promote further collaboration between teachers. The Hands on Science network coordinators supported teachers, not only in tapping European funding to be able to attend the conferences, but also by providing a system of finding contacts for those who were willing to undertake European transnational projects in science at their schools;

- ***Publications***: The network also supported the professional development of teachers through its publications. It has sought both to encourage teachers to present their examples of good practice to other teachers and to write short papers documenting their work. The network has published all the contributions in a number of conference proceedings (Divjak, 2004; Michaelides & Margetousaki, 2005; Costa & Vazquez Dorrio, 2006) as well as in a final 'Hands on Science' book (Costa *et al.*, 2008). These publications were distributed to the conference participants. They are also now open-access publications, as a soft copy can be downloaded from the project website. The aim of the open-access policy was again to allow as much outreach to teachers as possible. In addition, the project funds also made it possible to produce some hard-copy publications of small initiatives by the national coordinators. One example was a script text of a musical in science (Gatt *et al.*, 2006; Hands on Science & Azzopardi, 2005) and a teachers' handbook for primary school teachers (Gatt, 2005). These publications can still be downloaded from the project website, and national coordinators were responsible for distributing copies of the publications to key stakeholders in the different countries across Europe. Around 500 hard copies of the various documents were published.
- ***Comenius 2.1 in-service courses***: The network also provided opportunities for teachers to attend in-service training courses. Comenius 2.1 also fell within the then Socrates programme (now the Lifelong Learning Programme). Teachers can apply for a grant at their national agency to attend these courses where teachers from different European countries can meet and, while receiving training in new methodologies, can also interact with those of different cultures and education systems. The in-service training courses thus also helped to promote further teacher networking, supporting communication and collaboration beyond the short training period. There were ten courses in the Comenius database with over 100 participants and many more at local level in the different partner countries;
- ***Support for project proposals in the area of science education***: One of the aims of the network was to promote collaboration among teachers to carry out scientific projects together. The activities organised by the coordinators also served as contact seminars to bring together groups of teachers from different countries to try and find a common theme on which to base their collaborative project. The national coordinators thus had the responsibility of helping teachers to participate, as well as supporting them in putting together project proposals to be funded under the then Socrates Programme (now the Lifelong Learning Programme). In order to maximise the efficient use of funds, the contact seminars were organised in conjunction with the international conferences. A number of such successful project proposals were spinoffs of the network. The network coordinators were still

present in these projects, even if mainly in a supporting role, as schools worked and collaborated together. The Hands on Science groups were instrumental in getting more than 10 science Comenius projects under way. But there may be more which have been initiated, as contacts among teachers have been made in activities organised by the network;
- ***Organisation of Science Fairs:*** The network also launched a number of science fairs where teachers and students presented different types of practical experiments in science. In this initiative, it was possible for both to network and see what other schools were doing. In order to increase the exposure of these activities, the science fairs were organised in conjunction with the international conferences. One can now have a clearer view and understanding of how the international conferences have become larger and better attended with every year of the project. Science fairs have been the most challenging of all the activities, as it was difficult to encourage teachers and students to participate, but a number of small but good quality activities have been organised;
- ***Network website***: The purpose of the website was to provide information about the network to those who were interested in its activities. Its main role, however, was that of providing information about upcoming events and initiatives which teachers and schools, members of the network and beyond, could learn about. In addition, the main network publications, such as the conference proceedings, have been (and are still) on the project website for anybody interested in the teaching of science to download.

These activities within Hands on Science network can be considered to include various aspects highlighted as indicators of the high quality professional development (Supovitz & Turner, 2000) of their members. There were opportunities to increase and improve the teachers' personal content knowledge and pedagogical skills through participation in the thematic seminars, science fairs, and international conferences. Teachers, education researchers and teacher-trainers in science were provided with opportunities to share their work and plan to collaborate on new projects. These experiences and examples of good practices were also documented in the various conference proceedings and network handbook, which could be downloaded free of charge by anyone interested in improving the provision of school science.

Conclusion

Promoting and sustaining a network at European level is no easy task. One needs to take into consideration the different cultures, languages, and school systems, as well as the different approaches to dealing with similar problems across the different EU Member States. However, as the Hands on Science Network experience has shown, there is also potential for great contribution from this rich European diversity to work together in achieving one common goal: that of improving the type and quality of science education experiences which students across all Europe are receiving.

The success of the Hands on Science Network can be seen in its sustainability, as well as in its internationalisation beyond its funding period, which ended in October 2005. There is now a legally established Hands on Science Association which is based in Portugal. In addition, not only have the annual Hands on Science International Conferences continued, but the network has gone global with the conferences in Brazil in 2008 and in India in 2009. The success of this network is the fruit of the strong conviction, enthusiasm and commitment of those who have worked and continue to work together for a better education and for a more scientifically literate future generation. The network has also shown how people engaged in science education and working at different levels — in teacher-training institutions or universities, Science Faculties, Ministries of Education, schools and classrooms — can collaborate. These different players were able to share concerns and experiences on an equal level, thus helping many practitioners, mainly teachers, to find informal ways and contacts whereby they can look for ideas and initiatives to improve their everyday teaching in science. The Hands on Science network has provided that extra little push to bring about some of the highly needed changes in the provision of science education across Europe as advocated by the European Commission (European Commission, 2007).

Sustainability is one aspect which EU-funded projects suffer from once the funding period is over. This has not really deterred the members of the Hands on Science network. The coordinator has registered the network as a legal entity. While it may be possible to make it financially sustainable through membership fees, this has so far not been the case, as legal aspects take time and payment may deter teachers from participating. Nonetheless, the dynamism of the coordinator and the partners resulted in sustained initiatives to continue with the network's activities, even if on a lower scale, through other types of private funding in addition to what the EU funding can offer.

The Hands on Science network can thus be considered as one example of good practice in networking teachers and other education practitioners to promote teachers' professional development. Its ways of working can be easily transferred to other areas of education, should there be a number of dedicated and committed persons who are ready to sustain the network's aims and activities. In the same way that it has been and keeps operating in an open approach, based on mutual trust and respect, the network is also open to help others who want to learn from its experience in networking, even if it is not in the area of science education.

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