Science Municipalities – education for growth

Experiences and recommendations from the Science Municipality project 2008-2011

About this booklet

This booklet is mainly aimed at policymakers, school administrators, teachers and other groups of stakeholders concerned with science education. However, it should also appeal to industrial partners, local government officials, representatives of science centres and others interested in making a significant difference to science education. Its' purpose is to inform readers about a successful public development project in Denmark and to inspire readers to initiate efforts to secure the long-term development of science education. Most of the content of this booklet draws on the project evaluation, which involved the participating science education coordinators, other key stakeholders and the project manager. Many of the results and insights presented have previously been presented in other documents in Danish, but are brought together here to allow readers from a broader group to benefit from experiences from the 25 participating Danish municipalities. Among these documents are reports from both the annual evaluations and the final project evaluation, based on the work of researchers from Department of Science Education – University of Copenhagen.

Any views or opinions expressed in the booklet are the author's own based on the involvement in evaluating the project and the views do not represent the opinion of Danish Science Communication or any other organisation involved.

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Content

1. Introduction

In spite of large financial investments and a lot of attention focused on science education, there are only few examples of widespread sustainable improvements in science teaching. We are facing many challenges in order to ensure sound and inspiring science teaching with the potential of increasing children's interest in science subjects. Many promising public science education initiatives are in danger of disappearing if they do not receive the attention, which is necessary for their institutionalisation and for preventing them from drowning in new agendas. There is an urgent need for structures that can support, coordinate and ensure the institutionalization of the good science education initiatives sprouting in many municipalities. This is exactly the need that the Danish Science Municipality project tries to fulfil.

2. Science education in Denmark[1]

In order to benefit from the insights and recommendations presented in this booklet, it is important for the reader to understand the basic structure of the Danish education system. This will enable readers to draw their own conclusions about the applicability of the material in their own context.

2.1 Education for all

Denmark is a relatively small nation of approximately 5.5 million people with a healthy economy and a very long school tradition of public education, dating back to 1814. Personal income taxes are in excess of 50% in order to support the Danish welfare system, which covers education, medical care, social benefits etc. and which remains a fundamental priority in Danish society. One of the characteristic features of the Danish welfare system is that education is free for everyone at all stages of the educational system, from pre-school to PhD, with only very few exceptions. In addition, students from the age of 18 can apply for a state education grant to help them financially until they finish higher education. These two welfare choices combine to make the Danish education system one of the most expensive in the world compared to the number of citizens. The Danish education system consists of 3 levels: basic school, youth education and higher education, to which should be added

1) Section 2 adjusted from the summary report based on The Science Team K project, available at: http://formidling.dk/sw12217.asp

the area of adult education. Only the first two are discussed here in further detail:

- *Folkeskole* is a 9-year comprehensive school comprising primary and lower secondary.
- *Youth education* is either academically oriented (general upper secondary education) or vocationally oriented (vocational education and training).
- *Higher education* can be divided into: short-cycle (1-3 years), medium-cycle (3-4 years) and long-cycle (5-6,5 years) higher education.

Compulsory education lasts 9 years in the Danish school system and the majority of children in Denmark attend municipal schools called *"Folkeskole"*. Even though there are private schools, these are marginal compared to the public Folkeskole. Folkeskole is based on a "fail-free" system, which entails that it is virtually impossible for students to "fail" a year and usually only long absences can cause a child to be held back a year. In addition, there are no official examinations of any consequence before 8th. grade and it is rare for students to be formally graded in any subject before this grade. There is a final exam at the end of 9th. grade, which is the culmination of compulsory education. It is extremely rare for children to fail this exam and students are not legally required to take it. However, in order to continue to further education, students are required to pass a number of subjects. The grade point average has little consequence at this stage, as it does not directly limit students' options for further education. Thus, students with low marks have the same opportunities to continue to youth education (upper secondary) as students with high marks, although they may be encouraged to consider other education options by their teachers and parents.

2.2 Individual freedom

The Danish school system remains strongly influenced by the thoughts of N. F. S Grundtvig (1783-1892), who was the ideological founder of the Folk high school movement in Denmark. His thoughts about equality and the individual's right to pursue wisdom still remain at the center of Danish educational thinking. His opposition to exams, as being destructive for creative thinking, is still evident in the Danish "fail-free" system.

Denmark has a tradition of decentralized education with few national standards or requirements, allowing a great degree of freedom regarding many decisions about what and how to teach in each particular subject. Teachers are, however, required to plan their yearly curricula in accordance with local guidelines and local school administration. In spite of a decentralized system, administrative duties and organisational constraints sometimes restrict teachers from engaging in development initiatives or teacher collaborations and networks that could improve the quality of teaching. The high degree of freedom afforded teachers can,

however, be detrimental to the quality of teaching, as teachers are required to make an overwhelming number of decisions and many teachers conform to teaching traditional subjects in traditional ways rather than exploring new pedagogical territory. Every teacher in the Folkeskole must document each individual student's progress. This is an example of a student-centered educational system, where consideration for the individual pupil often outweighs other considerations such as teacher qualifications or needs.

2.3 Science education

Science is divided into four separate subjects in the Danish Folkeskole, one of which is taught as a comprehensive science subject in the first six years of schooling. From 6th. grade science is divided in to traditional science subjects: biology, geography, physics and chemistry. There are significant differences between the groups of teachers teaching different science subjects and the challenges they face. However, several issues permeate Danish science education and there have been confound attempts of improvement.

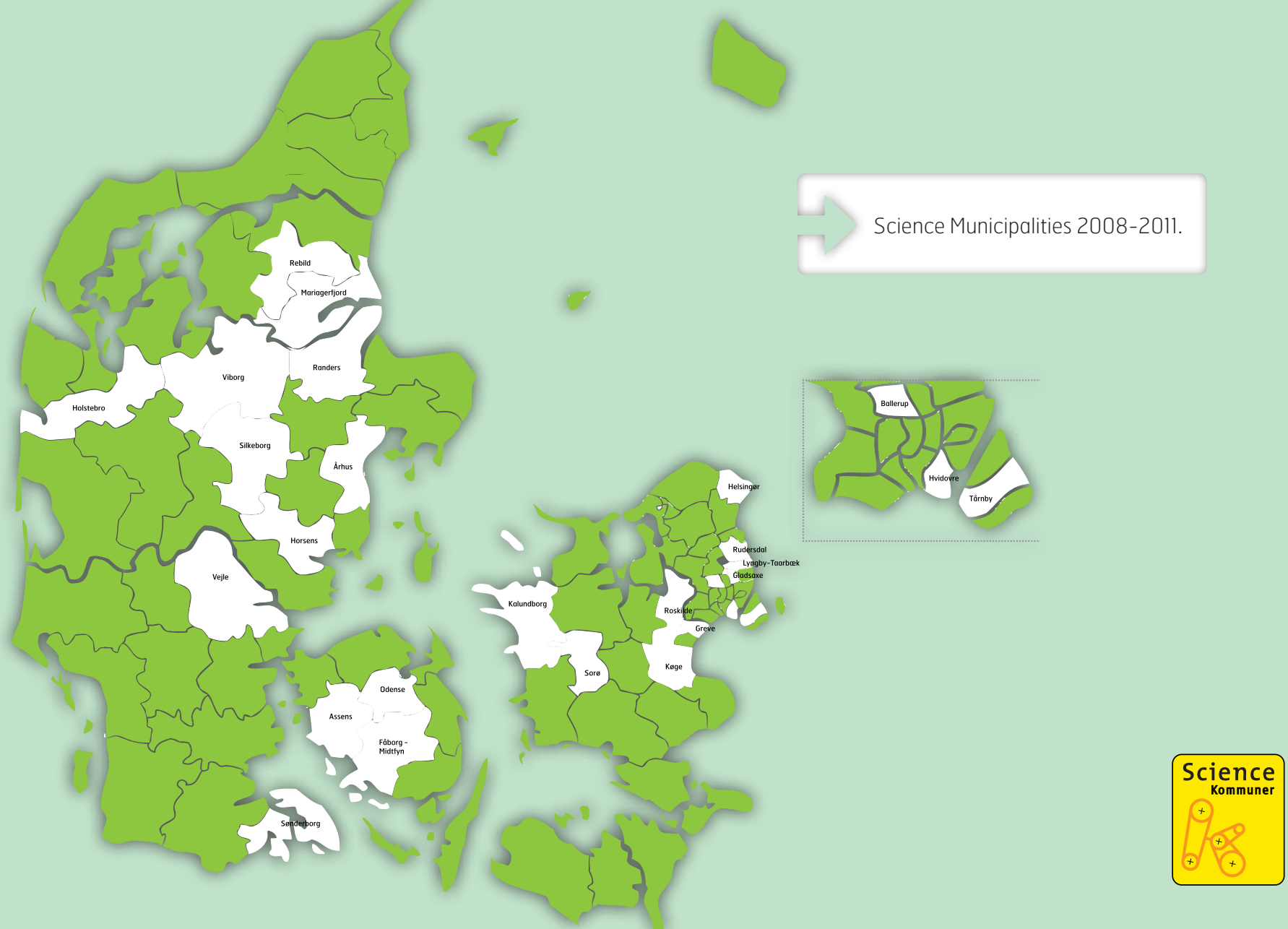
Three of these issues are worth mentioning here:

- Lack of time, energy and resources: Science teachers are besieged by innumerable tasks that make it difficult to engage in any long-term effort to improve teaching. Without time to develop professionally and lacking the necessary resources to realize new ideas, many attempts to improve science teaching end up short-lived and contrived.
- Too many science teachers in the Danish Folkeskole lack the necessary content knowledge and teacher competencies to deliver high quality science teaching.
- A final issue that is central to science teaching throughout the educational system is the lack of teacher collaboration and coordination of subject matter taught in science classes. Science teachers could draw benefit if they were afforded more time and opportunity to work together.

These three general issues might help to explain some of the poor Danish results in international comparisons. According to OECD reports, European countries such as Denmark, Hungary, Finland, Italy and Germany have experienced a relative drop in university graduates with scientific and/or technological degrees[2]. Also, the 15-year olds (especially girls) show very little interest[3] in pursuing and engaging in science and technology when compared to students in other Nordic or other comparable European countries. Considering the high expenditure on the Danish educational system, these results fall short of expectations.

[2] OECD (2006). OECD Science, Technology and Industry Outlook, OECD Publishing.

[3] Busch, H. (2005). Is Science Education Relevant? Europhysics News (September/ October), 162-167.


Science Municipalities 2008-2011.
Rebild
Mariagerfjord
Viborg
Randers
Holstebro
Silkeborg
Århus
Horsens
Vejle
Odense
Assens
Fåborg - Midtfyn
Sønderborg
Kalundborg
Sorø
Helsingør
Rudersdal
Lyngby-Taarbæk
Gladsaxe
Roskilde
Greve
Køge
Ballerup
Hvidovre
Tårnby
Science
Kommuner

3. Science Municipalities 2008-2011

3.1 Background

Development and growth in the field of science and technology is needed to ensure continued prosperity in many European countries, including Denmark. As many other countries, Denmark is unfortunately also in danger of facing a lack of highly competent science graduates in the future. Students' lack of interest in science subjects has therefore been a growing concern – and it still is.

It can be extremely difficult to achieve the long-term educational changes needed in order to make sure that more pupils choose a profile within the science subjects during their higher education and in the future pursue a career in the field of natural science. This recruitment problem is the underlying reason why the former Danish Ministry of Science, Technology and Development, the Ministry of Children and Education and several private companies and other organizations, which depend on qualified science graduates, have begun to fund projects concerning development of science education.

One such project was the regional project, Science Team K (2003-2006)[4], which aimed at increasing the interest for science and technology among children and youngsters in one Danish region. The Science Team K project served as a pilot study for the Science Municipality project (2008-2011) involving 25 Danish municipalities. The project was managed by the NGO, Danish Science Communication. The lessons learned from the many stakeholders involved in the 25 Science Municipalities will be shared for your inspiration in this booklet.

3.2 The Science Municipality project

The Science Municipality project was a national three-year project aimed at improving conditions for science education in 25 Danish municipalities. The project was a part of the national strategy for development of science education and was funded by the Ministry of Children and Education. After being informed about the project, about half of all 98 Danish municipalities expressed their interest in the project and finally 25 of them were engaged in the project with acceptance from the local political leaders. This meant that 1/3 of all Danish pupils were affected by the project.

The purpose of improving conditions for science teaching was to increase pupils' interest in science and technology in order to inspire more pupils to pursue a science profile during higher education

4) Further information available at http://formidling.dk/sw12217.asp

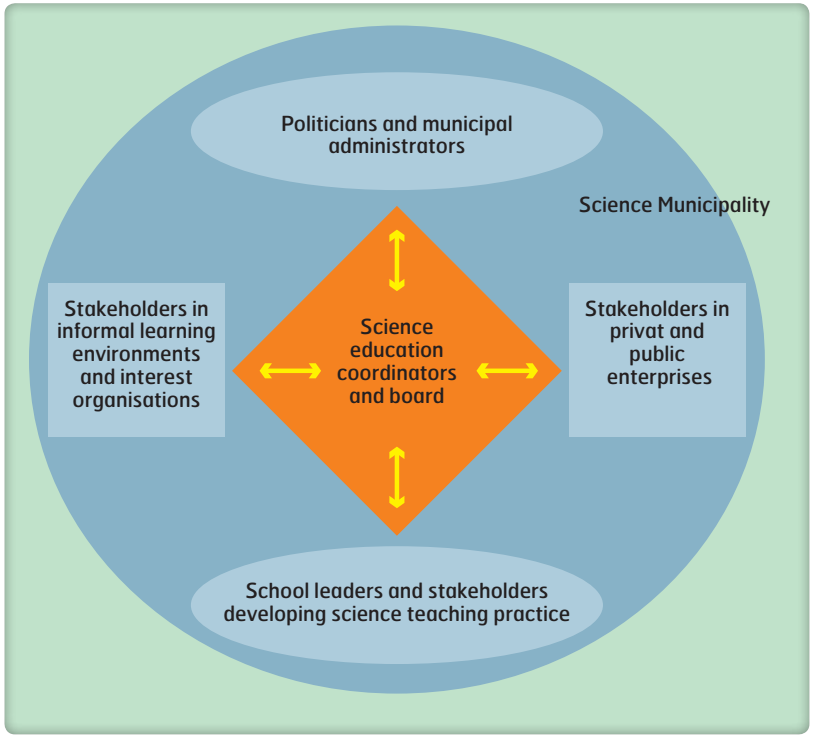


Figure 1: Model of stakeholders in Science Municipalities.

and hopefully beyond. Experiences from the pilot project, stressed the importance of establishing precautions to ensure that the development was not just temporary and limited to the project period. Based on these lessons, the focus on ensuring a sustainable progression was a great concern in the Science Municipality project, and elements, constructed to support permanent effects of the effort, constituted the project model. The overall idea with implementation of the model was to increase the utilization of existing science education initiatives and resources, more than it was an effort to initiate many new costly projects.

3.3 Project elements

The Science Municipality project was based on a model consisting of elements establishing supportive conditions and networks on several levels in each Science Municipality (see Figure 1). The main core in this model was the link between the different networks of stakeholders either directly or indirectly involved in science education.

Science education coordinators

In each Science Municipality at least one science coordinator was designated. To place the science education coordinators in an international context, their position can be compared with an LEA (local education authority/agency) adviser, but with science education as focus of interest. The coordinators were responsible for creating an overview of existing resources in the field of

science education and coordinating existing and new initiatives. The coordinators preferably had connection to both the local schools and the municipal department.

Science education boards

The Science Municipalities each formed a science education board with members from a variety of important organisations and institutions within the municipality, e.g. the formal education system, informal learning environments (science centres, museums etc.), local enterprises as well as representatives from the political system in the municipality. The members of the boards were the science education coordinators' closest collaborators and they were engaged in several activities such as coordination of the science education resources, designing new initiatives and branding the Science Municipality project on many organisational levels.

Science teacher networks

To establish not only the top-down approach to science education improvement, but also bottom-up engagement, an important element in the Science Municipality model was professional networks for science teachers. These networks facilitated reflective teaching practice and collaboration about improving science teaching methods. The science teacher networks were appropriate forums for linking teachers from primary, lower and upper secondary education and for sharing knowledge about local science education initiatives, thus ensuring that the existing resources were brought into play.

Science education strategy

One important cornerstone in the Science Municipality model was formulation of municipal science education strategies. Such strategies were often formulated by the science education boards, and the content should preferably be aligned with the municipal business strategy. The strategies were unique for every municipality and thus differed from each other according to the present agendas in the municipalities. Areas of priority in many science education strategies were science teacher networks, funding opportunities for new initiatives, facilitation of schools' use of informal learning environments, organisation of recurring science events, professional development for in-service science teachers, etc.

Regional and national networks for science education coordinators

The science education coordinators were engaged in both regional and national networks. The coordinators attended meetings in their regional networks twice á year, and biannually national network meetings with all coordinators were arranged by the project manager. During these meetings the coordinators shared their experiences and relevant speakers were invited to enrich the coordinators' work with inspiration and effective tools for further progression.

4. Insights

4.1 Science education coordinators as driving forces

It was crucial for the Science Municipalities that local science education coordinators were appointed to coordinate activities and facilitate the distribution of information about science teaching initiatives among schools and teachers. When the science education coordinators established an overview of the existing resources in the field of science education in the municipality, it became possible to bring different stakeholders together very quickly. It was important that the overview did not only depend on one single science education coordinator, but that the knowledge and overview was distributed among several involved stakeholders, to prevent a fragile structure without precaution for future organisational changes such as replacements of coordinators.

4.2 Coordination of municipal networks

"Networks are purposefully led entities that are characterized by a commitment to quality, rigour and a focus on outcomes... They promote the dissemination of good practice, enhance the professional development of teachers, support capacity building in schools, mediate between centralized and decentralized structures, and assist in the process of re-structuring and re-culturing educational organizational systems."

(OECD's definition of networks, quoted in [5]).

The definition of networks formulated by OECD gives resonance to the municipal networks in Science Municipalities. The networks constituted the science education boards, science teacher networks and the coordinators' and board members' networks among stakeholders both in schools, informal learning environments, local enterprises and municipal departments. The networks were in large part led by science education coordinators, with improvement of science education as a shared and common purpose. The networks nurtured relations between stakeholders and these relations facilitated alignment of the agenda from organizational levels in the municipality (municipal administrations, departments and politicians) and the capacity for development in the decentralized units (e.g. schools, science centres etc.).

4.3 Benefit from external stakeholders

Many external municipal stakeholders outside schools play a pivotal role in developing and maintaining adequate conditions for improvement of science teaching. These stakeholders come from a wide diversity of municipal institutions, e.g. municipal departments for school development, local enterprises, informal learning environments (science centres, museums etc.) - just to name a few. The Science Municipality model was an attempt to coordinate these stakeholders in networks, so that the municipalities

[5] p. 53 in Jackson, D. & Temperley, J. (2007). From professional learning community to networked learning community. In Stoll, L. & Louis, K. S. (Ed.), Professional learning communities: Divergence, depth and dilemmas. Open University Press.

were able to draw benefit from all the existing resources with connection to the area of science education. The formation of science education boards in each municipality was an attempt to organize the school external stakeholders in networks so they could contribute to development of science teaching in the best possible way. By gathering all the different stakeholders in a science education board it became possible to bring all human resources, knowledge and possible teaching facilities into play for the benefit of better science teaching. Formulation of science education strategies was one way to foster accountability towards the science education effort among the many stakeholders from different organisations in the municipality. Involving these different stakeholders in the process of developing the strategy could serve at least two purposes: it could nurture the feeling of ownership towards the initiative and it could facilitate the implementation of the strategy when the strategy was disseminated peer-to-peer. The strategy also served as a common reference and communication tool for the external stakeholders as well as for the people directly involved in science teaching in schools.

4.4 Relations carry development

The networks in Science Municipalities are entities (as in OECD's network definition), but to understand their relevance one must take a closer look at the members comprising the network. The networks were not just groups of people collaborating for the common purpose of improving science education. The networks were in larger part constituted by the relations between the members. The Science Municipality model fostered relations between the many involved stakeholders in each municipality and the project facilitated these networks of relations by stating a common goal and vision for the collaboration. Personal relations were emphasized by the science education coordinators as keys to success in the networks established between different organisations in the municipality. Relationships are of high importance for developing, improving and maintaining results of a common municipal effort for science education improvement.

4.5 Political engagement is crucial

Political decisions and agendas in municipalities have consequences for all development processes in school districts, because politicians can provide or withhold adequate resources for progression. To ensure political support and commitment to the effort was an important goal in the Science Municipality project. A widespread political awareness was crucial for the prioritization of science education among administrative stakeholders. Political attention created a strong incentive for school leaders to prioritize development in science teaching in their school. Through political support, it proved to be possible in many Science Municipalities to maintain

a common effort for science education in many schools, and this in spite of a decentralized distribution of the funding for school development. The political engagement legitimized the effort - time, economy and human resources - invested among school leaders, teachers and other important stakeholders.

> Our politicians can see the relevance and usefulness of the idea [the Science Municipality project]. This project is now embedded in the municipality's school department as well as in other departments."
> *Science education coordinator*

4.6 Development from existing conditions

There are large differences in the internal organization of individual municipalities. Many factors, such as municipality size, number and types of educational institutions, local enterprises, informal learning environments, economy, composition of municipal departments and local politics have significant impact on education development in a municipality. Therefore it was not possible to construct a generic ideal procedure for a science education effort, which suited all municipalities – and this was not the intention with the project. Nor was it possible to define a clear set of success criteria, which were applicable in the assessment of the science education effort in all municipalities. The success must be assessed with a view to the barriers and resources existing in the municipality.
A central idea behind the Science Municipality project was that the participating municipalities had to define their own goals and time frames concerning the local constraints and opportunities for improving science education. This concept helped to ensure a strong ownership among the involved stakeholders and it offered the opportunity to establish, not generic formal partnerships, but meaningful relations between local schools, informal learning environments, private enterprise and the municipal school administrations.

4.7 Bottom-up and Top-down approach

From the experiences gained in the 25 Danish Science Municipalities, it was clear that local political engagement was necessary but not sufficient in itself to ensure the benefit from a municipal science education effort. Political support for science initiatives was necessary to ensure adequate conditions (e.g. resources and time) for development of science teaching. During the Science Municipality project it proved to require one or more persons who could not only "walk the talk" in the

political system and hence function as ambassadors for the project, but who also had the authority to influence decisions at the political system. This role was often fulfilled by the science education coordinators in collaboration with the science education boards.
But even politically accepted science education efforts do not lead to a sustained development, if they do not find resonance in practice. The science education coordinators and the science education boards constituted a mediating level between schools (teachers and school leaders) and external stakeholders in the political and administrative levels in the municipality. This network was a prerequisite for aligning the development of science teaching at school level with the political agenda. When municipal supportive structures are established, as was the case in Science Municipalities, it provides fruitful conditions for teachers' and school leaders' necessary engagement in the inspiring development of new improved science teaching. This lifted the field of science education in many municipalities.

"Successful reforms are not top-down quick fixes to problems nor are they bottom-up solutions to immediate needs; they are collaborative, local programs of long-term change" [6].

4.8 The time aspect

That education development takes time was the most evident but perhaps the least surprising experience from the Science Municipality project. It took time to cultivate, nurture and develop the relationships that carried the initiatives and progression. A time span of three years is not sufficient to explore the full potential of a project involving as complex organisational structures as was the case in the Science Municipality project. At the end of the project, the Science Municipalities were at different phases of development. Despite this, the model of a coordinated municipal effort has shown great potential for development of science education by securing a better exploration of science resources in the municipalities. Essential for optimal utilization of the potential were the supportive structures facilitating the interplay between stakeholders placed on all the levels in the municipality - that is formal and informal learning environments, municipal departments and political systems.

[6] *p. 48 in Ellis, J. D. (1995). Fostering Change in Science Education. In Innovating and Evaluating Science Education: NSF Evaluation Forums 1992-94.*

5. Recommendations

Based on the annual reports from the formative project evaluation, we present here the most important recommendations from the Science Municipality project. The recommendations are based on the experiences from the municipal science education coordinators and the project manager and can be used as inspiration by others who wish to establish a coordinated effort for improved science education in their municipality or local region.

5.1 Form a science education strategy

A politically accepted and supported science education strategy can ensure the prioritization of a common targeted effort among the many relevant stakeholders who have an influence on science education directly or who play an important role through their impact on the conditions for performing professional science teaching. In order to lead to the desired positive changes in science education, implementation of the strategy's visions and goals must be facilitated by competent personnel who understand the agendas from the administrative level in the municipality and the conditions for development in schools. This is a prerequisite for implementing the visions from paper to practice.

5.2 Ensure political support and foundation

Local political commitment and engagement is essential for implementing successful municipal science education efforts, because this support spreads to the administrative leaders in the municipal departments. A commitment from these levels in the municipality's political system legitimizes a high priority of science education among school leaders and teachers. Science education coordinators and boards should be engaged with the focused and sustained effort, which is required to achieve the political attention.

5.3 Designate science education coordinators

Science education coordinators with extensive networks both in schools, municipal departments and in the political system are crucial for establishing coordination of a focused and shared effort for improved science education in municipalities. They play crucial roles in sustaining the development during and after the project.

5.4 Form a science education board

A quorate science education board should comprise representatives from all types of municipal organisations with connection to science education. Such a board is an ideal forum for development of a science

> The teacher networks are now voluntary and the teachers do not get allotted time to attend the network. Nevertheless, teachers still sign up for various network activities".
> *Science education coordinator*

education strategy. The board members are indispensable partners for the science education coordinators and they are necessary for maintaining the focus on science education both among politicians and among internal stakeholders in schools.

5.5 Support science teacher networks
Networks for science teachers are necessary for science education improvement for at least two reasons. The science education coordinators benefit from the networks in the process of establishing the necessary overview of resources in the municipality, and the networks are forums where the many coordinated initiatives can be brought into play among the teachers. The most fruitful science teacher networks are formed on the basis of voluntary participation, where teachers have a voice. Effective teacher networks must also have a facilitator – a role ideal for the science education coordinator.

5.6 Establish collaboration between various stakeholders
Inter-institutional cooperation between stakeholders, both internally and externally linked to the educational system, possesses great potentials for enriched development of science teaching in municipalities. The collaboration requires facilitation, time and personal relationships. Even though the incentives for the broad variety of stakeholders to engage in such collaboration may differ, a common interest and wish to improve science education must be shared among the stakeholders. The collaborations can be carried by specific projects with initial and ongoing clarification of expectations between the stakeholders.

5.7 Gain overview of resources
A municipal coordination of science education initiatives requires that science education coordinators provide an overview of existing and pipeline initiatives. Such an overview emerges from the coordinators extensive and diverse networks. To avoid a temporary and fragile overview it must be distributed to more stakeholders than a single coordinator - preferably the science education board.

5.8 Brand the project
Public branding of an effort for science

education improvement is important because promotion of the initiative serves to build a momentum and awareness among many stakeholders. To brand the initiative in the media can motivate the involved stakeholders whether they are teachers, politicians or other stakeholders involved. Branding of the effort, e.g. on the municipality's website, also increases the transparency and hence makes it easier for stakeholders to establish new relations and collaborations.

> It's nice to have someone who just has the big picture when you are sitting and drowning in your own little project".
> *Upper secondary teacher*

Concluding remark

Our research in the 25 municipalities showed that the elements in Science Municipality model support the relations between internal stakeholders in schools and the many external stakeholders who possess the capacity and potential to contribute to development of improved science education.

The Science Municipality project was funded by The Lundbeck Foundation and The Danish Ministry of Children and Education. The project was managed by Danish Science Communication and the evaluation was conducted in a research based collaboration with Department of Science Education - University of Copenhagen. The insights and recommendations presented here are based on these evaluation reports.

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DEPARTMENT OF SCIENCE EDUCATION
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