AIM
The aim of this paper is to raise questions about the process of systemic innovation involved in policies and practices designed to promote science and technology education in Iceland. We use an OECD definition of innovation (OECD, 2007a):

*Innovation is any kind of change that is introduced with the aim of improving the operation of educational systems, their performance, the perceived satisfaction of the main stakeholders, or all of them at the same time.*

We consider support for innovations in terms of finance or external support, professional or research agencies or networks of innovators. We look for connections between research evidence and innovation, whether innovation is driven from the centre, the openness to bottom-up innovation, the channels for development and the roles of stakeholders (OECD, 2007).

Iceland is an island country, wealthy, with a very high standard of living and a population of 310,000 of which about 93% of the population lives in communities that are larger than 200 people, and about 63% live in the Greater Reykjavík area (Statistics Iceland, 2008). Iceland have a life-expectancy of almost 80 years. Iceland has a unique language and culture stretching back in time over 1100 years. Iceland was ranked with the highest Human Development Index (HDI) in the world in 2005 (UNDP, 2007) and typically ranks a little below the OECD means in PISA studies (OECD, 2007b).

PROCEDURE
The study draws on two lines of experience and inquiry. Both authors have been involved in a research project *Intentions and reality* since 2005 on the status of science and technology education in compulsory and secondary schools in Iceland. The findings build on an analysis of policy documents, as well as visits to schools, interviews with teachers and administrators, students, curriculum writers and other stakeholders, for example, producers of curriculum materials. One author was involved in the formulation of national science and technology policy from 2000 to 2006 and an evaluation of educational research from 2003-2005.

NATIONAL POLICIES
*Education in national science and technology policy*
The main line ministry for education and science in Iceland is the Ministry of Science, Education and Culture, one of the largest of the twelve ministries in the Icelandic government. Thus general issues of science, research, education and science education all fall under the same ministry. Several ministries however fund their own research institutes. During the period 1994-2003 the formulation of research policy was in the hands of an advisory body, the Research Council, which submitted recommendations to the Ministry. In 2003 science and technology policy became part of a combined decision-making process when cabinet ministers were appointed directly to a new policy council.

Education and the need to encourage young people to enter science and technology was mentioned early on in a policy document from 1998 on research for the 21st century (Rannís, 1998). The next national policy document from late 2003 was almost entirely focussed on science and research in universities and national institutes and the strengthening of competitive funds
Education and science education were not mentioned formally but the Minister of Education established a committee to discuss ways to increase the interest of young people in science. The policy document published in 2006 emphasised the role of education, listed ways in which education could be strengthened and mentioned particularly science and technology education for young people (STPC, 2006). This policy was followed up by a vision for the future in 2007 in which education and educational research were highlighted (STPC, 2007).

Science, technology and innovation form a continuum in these policy documents, though it seems that (pure) science is favoured by one competitive fund and innovation by another. The classification scheme used for recording areas of research does not readily reflect new areas of research. The approach to research policy and innovation by the Ministry is to identify key issues and then allow individual scientists to compete with each other for funding through a process of peer review of grant proposals. At the moment it seems easier to grant proposals to science and innovation, but technology (as a development process) is less likely to be funded, and technology proposals are sometimes moved back and forth from one committee to another.

**Education policy and the national curriculum**

A national curriculum for compulsory education was issued in 1989 some time after significant reforms in the 1970s. With new political alliances in the early 1990s the decade became a period of considerable change. A governmental committee presented a report in 1993/4 on the desirability of new policies in education. New laws were passed with regard to preschools in 1994, compulsory schooling in 1995 and upper secondary schooling in 1996. Control of compulsory schools was passed to local authorities in 1996.

New national curriculum guidelines for all school levels were issued in 1999 (Ministry, 1999a, 1999b). The general approach in the revisions was that the aims were prepared by expert committees and then teaching objectives were prepared by teachers or teacher educators. A few years later the national curriculum was again revised, with the extent of the revisions varying considerably between subjects. Both the 1999 and the 2007 versions have the same general structure with aims written for grades 1 to 4, 5 to 7 and 8 to 10. Schools have until 2010 to adapt their own school curricula to the newest national curricula. An optional national examination in science in the grades 9 or 10 was reintroduced from 2002. In the 2007 version the detailed objectives in the 1999 science curriculum have disappeared. A new area on information and technology education was introduced in 1999, with sections on information studies, innovation and the practical use of knowledge and design and construction. In 2007 the chapter on design and construction was moved into a separate booklet at the request of carpentry teachers.

**AGENCIES**

**National agencies**

Several national agencies promote national policies on education and on science.

The National Centre for Educational Materials develops printed and digital materials. In the wake of the new curriculum in 1999 some additional funding was allocated to the NCEM for the next two years for the development of new learning resources. It adapted and translated a set of science materials from the USA for use in grades 8-10 in the late 1990s and published new materials for physical science in grades 5-7 in 2000 and 2001. Digital materials are usually either pdf-versions of teacher guides or web-sites. The Centre does not put on the web that which can be put in books (NCEM, 2001). Both the Ministry through the national portal, the Educational Gateway [http://menntagatt.is](http://menntagatt.is) and a private company, the School Web, have put curriculum related materials, often developed by teachers, on the web. The former site is poorly funded and
staffed. The latter applies for and receives project grants and has schools and parents as paying subscribers and a staff of 8-10 people.

The Research Centre of Iceland [http://rannis.is](http://rannis.is) and several other organisations, many energy-related, offer science events for the public and for schools. Attempts are underway to build a science centre and a technology centre.

The Ministry and some local authorities offer competitive funds for school projects, but science has not been targetted directly since 1997 and 1998 although information technology and environmental education have more recently received a few grants. The Ministry also offers some competitive funding for inservice courses, a small percentage of which are science-related. These project and inservice grants range in amount from USD1,000 to USD10,000.

The Ministry itself undertakes evaluations of selected schools each year and monitors the extent to which schools engage in self-evaluation as required by law. The National Testing Institute conducts national examinations in six subjects at the end of compulsory school. About half of the year class choose to take the science examination. The Institute is responsible for all practical and professional aspects of Iceland’s participation in such studies as PISA and TIMSS.

**Other stakeholders**

Local authorities are required to provide the facilities, teachers and support services for all children of school-going age and thus for maintaining and upgrading science facilities. Individual principals are ultimately responsible for policy and the curriculum within their schools.

University staff and students carry out research in science and technology education and respond to requests for advice and support from schools. Three professional organisations of science teachers exist and have held jointly and separately both national and Nordic conferences on science teaching and on research in recent years. Several universities hold 1-2 day conferences, with perhaps 5/100 presentations on science projects. There are several general journals about education and for educational research, three of them peer-reviewed and one of which is on-line. There is on average one article on science or technology education per issue.

**FINDINGS**

Approaches to systemic reform of school science are typically the alignment of two or more of the following: curriculum, instruction, teacher preparation, assessment, graduation requirements, school governance and school climate and ethos (Knapp, 1997). Most commonly though attempts are made at systemic level to align curriculum frameworks, textbooks and assessment. The new curriculum guidelines in 1999 in Iceland were introduced into a decentralised school system with individual schools responsible for preparing their own curriculum. In the classroom however teachers rely on printed materials. Research carried out in middle school classrooms in Iceland nearly 20 years ago showed that printed materials, usually from the NECM, are used by teachers for the major part of every lesson (Sigurgeirsson, 1992, Macdonald, 1993). Recent research, some of it unpublished, indicates that the same types of teaching practice are still dominant, i.e., printed materials are the mainstay of classroom lessons (Karlsson, 2007, Authors, in preparation).

Thus one plausible approach for (science) curriculum innovation in Iceland to reach classroom level is indeed to align national curriculum guidelines and materials used in lessons. Other approaches require more effort, such as investing in inservice training, or may be tactically inappropriate such as working closely with local authorities and individual principals as professional leaders in schools. In a separate study we have considered the case of a local authority which chose to follow national policy and support science education in schools through the provision of resources and inservice training, contacts with local business and professional support (paper submitted to NARST 2009).
Thus a key agent of innovation in science education in Iceland is the policy adopted by the National Center for Educational Materials, which decides how to use funds allocated to it in the national budget. New science texts were prepared for middle school and elementary school science in the early 2000s, strongly aligned with the objectives in the new curriculum guidelines. Use of the new books have not been formally evaluated but recent research indicates that the middle school physical science books tell two stories (see below). Texts at junior high level (grades 8-10) had been prepared in the late 1990s, before the new curriculum, and were translations and adaptations of a textbook written in the United States.

In a recent analysis of the middle school textbooks by the authors (Authors, 2008, in preparation) we found that the written text used ‘non-specialist” terms, straightforward sentence construction, declarative language and there was often no clear author or source. No clear distinction was made between scientific knowledge and everyday knowledge and the overall message was that Everybody can learn science! An analysis of the images indicated that teachers were often needed for further explanations, that images were everyday and didn’t show “discrepant events”, that in about one-quarter of the images there were cartoons with no clear criteria of what constitutes scientific knowledge and that the use of familiar images such as Lego blocks could confuse rather than promote understanding. The message of science being presented in the images was that Science is not really amazing!

We explored teacher views on these curriculum materials. Generally we found that teachers liked the books. Two teachers were selected for closer analysis. A teacher with a reasonably strong background in science said: The books are just wonderful, they are among the best books for this age-group but she added that they didn’t do all the practical work, and that if a person did not feel confident in the area then it would be very difficult for them to work with the books. She thought that her students had fun doing physics. However another teacher with a much weaker background said I think the books are tedious and added that she hadn’t done much practical work with the class and that the books were boring to read. She felt that her students had to behave well enough to earn the right to practical work. She expressed an interest in attending an in-service course. We wondered what science reached the classroom in the hands of these two teachers.

The policies for science education as reflected in the curriculum guidelines and the textbooks seem on the surface to be sound and are in keeping with developments elsewhere – students learning to work like scientists, all students able to learn science (Duschl, 2008) and the nature of science, which received so much attention in the late 1900s is on the agenda. There is a fault line however, with new developments on the one side and older on the other. The approach to school science in the curriculum and the textbooks discussed here is essentially reactive, laying out acceptable views of science as knowledge and science as method. Innovation is not considered to be problematic, ideas are to be transferred from author to teacher, from printing site to school classroom. Lessons emerging from learning research and science studies are not being learnt (Duschl, 2008).

SUMMARY AND CONCLUSION
Little support was provided in terms of finance or external support for the innovations in the national curriculum of 1999. No networks or research agencies were created around the process of developing the curriculum and it was not until researchers/teacher educators and the small association of science teachers in compulsory schools joined forces in late 2005 that there was a real professional venue for sharing of experiences. The innovation was proposed by the central authorities but not followed up by centralised support measures; decentralised and weak funding measures were put in place. It was somehow thought that individuals would align themselves
with the policy, develop materials and evaluate outcomes. It is debatable whether this approach can be described as “openness to bottom-up innovation” or an abdication of responsibility.

One further note of caution. Reform efforts often assume that with sustained calls for change (e.g. a new curriculum) and some outside support that teachers will begin to adopt recommended practices (Rogan and Grayson, 2007) but a drawback is that it seems as if “the task is one of transfer of ideas rather than the ideas themselves” (own italics, Knapp, 1997, p. 250). Working with scientific skills and methods, and understanding and working with the nature of science, are not simple bits of information, but are in fact ideas that require a level of understanding and seldom found among elementary school teachers or policy-makers. Duschl (2008) has argued forcefully for balancing conceptual, epistemic and social learning goals. Such goals are indeed ideas that need further discussion in the search for innovation.

REFERENCES
Statistics Iceland [n.d.] http://www.statice.is/