Intention and reality: science and technology education in Iceland

Final report
Submitted to the Research Fund of Iceland
December 2008
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Part 1
Participants and their role in the project
Abstract - main aims and results, success/gains
Conclusions and discussion
List of publications (reports, papers, other)
1.1 Purpose and participants

The purpose of the *Intentions and Reality* project on science and technology education (IR project) in Iceland was to follow up on evaluation research carried out from 1991 to 1993 on the *Status and future of science education in compulsory schools in Iceland* and funded by the Science Council (Macdonald, 1993a). The IR project received most of its funding from the Research Fund of Iceland for the years 2005 to 2007. It was based at the Iceland University of Education. Some parts of the project were funded by the Research Fund of the Iceland University of Education. In addition the work in one municipality was funded by Garðabær and Marel. A grant was also received from the Innovation Fund for Students.

Project participants included:

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<tr>
<td>Allyson Macdonald professor/project leader</td>
<td>Preparation for data collection</td>
<td>Data collection and report writing</td>
<td>Report writing; conference talks</td>
<td>Preparation of articles for publication</td>
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<td>Auður Pálsdóttir adjunct/specialist</td>
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<td>Björg Pétursdóttir specialist</td>
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<td>Kristján Ketill Stefánsson student/adjunct/assistant</td>
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<td>Meyvant Þórolfsson lecturer</td>
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<td>Elín Bergmann Kristinsdóttir student/assistant</td>
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<td>Haukur Arason lecturer</td>
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<td>Hrefna Sigurjónsdóttir professor</td>
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<td>Stefán Bergmann senior lecturer</td>
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<tr>
<td>Hrafnhildur Pórólfsdóttir assistant</td>
<td>General duties, proofreading and transcription</td>
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1.2 Goals and research questions

The goal of the IR study was to trace changes in the provision of science education in the late 1990s and early 2000s following changes in the law, a revised national curriculum, the re-introduction of a standardised examination in science and the participation of Iceland in international comparative studies. These changes have occurred against a backdrop of developments in science and technology itself, the need for a scientifically and technologically literate workforce, the role of information technology in modern life and the massification of secondary and higher education.

The value of the study lies in the contribution it can make to the development of science and technology education in Iceland in the 21st century and to discussions regarding proposed changes in lower and secondary education. The study addressed the research questions shown in Table 1.1.

Table 1.1. Research questions in the IR study on science and technology education

<table>
<thead>
<tr>
<th>Main research question</th>
<th>Subsidiary questions</th>
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<tr>
<td>What is the nature of the gap between the intended curriculum and the actual curriculum in school science and technology – the intentions and the reality?</td>
<td>What are the main features of the national curriculum in science in Iceland from 1999 (and 2007)?</td>
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<td>What resources are available for science teaching and learning (particularly ICT) and what is their role?</td>
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<td>What learning and teaching practices are typically found in schools?</td>
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<td>What influences student choice with regard to science and technology in secondary, further and/or higher education?</td>
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Data collection involved analysis of the national curriculum in science from 1999 for compulsory and secondary schools (and later from 2007) and other policy documents, analysis of a selection of school curricula, an analysis of some of the results of the PISA 2006 survey, and analyses of student interest in science, in school science and in science related studies or occupations.

The study also involved on-site visits to compulsory and secondary schools in five areas of Iceland. This required the preparation and use of an electronic questionnaire to be answered by teachers (only in compulsory schools) and the analysis of the results. This questionnaire enabled teachers in each school to engage in an evaluation of the school’s capacity to deliver science and innovation education prior to the visit of the researchers, and the results formed part of the discussions with the teachers.

Protocols were developed for interviews with students, teachers and principals, as well as a checklist regarding school facilities and a checklist for classroom observation. All interviews were recorded on a digital recorder, with the permission of the interviewees. Some interviews must still be transcribed and a more thorough analysis carried out of themes emerging from the data. One preliminary study of the ‘science story’ told in a middle school textbook has been carried out and a survey of ICT resources is underway. The classroom observations (about 24 different lessons in compulsory schools) are being summarised. A detailed case study on innovation education was carried out in one school.

Participants have written reports on the school visits and a variety of presentations at conferences, seminars and workshops has been made since 2006 (see the list of published material). Several articles are being prepared for submission to peer-reviewed journals.
1.3 Main results

<table>
<thead>
<tr>
<th>What are the main features of the national curriculum in science in Iceland?</th>
<th>What resources are available for science teaching and learning (particularly ICT) and what is their role?</th>
<th>What learning and teaching practices are typically found in schools?</th>
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| **1999 curriculum** The science curriculum from 1999 indicated that learners should develop a good understanding of:  
  - The nature and role of science  
  - Science content  
  - Methods and skills used in science  
There were three content areas: physical sciences, earth sciences and life sciences which were to be integrated with two thematic areas concerning the nature and role of science, and methods and skills. Detailed objectives for the content areas for each grade were presented in the 1999 curriculum. The goals for science learners in the 10th grade reflected these areas and themes. Students were to:  
1. Develop a broad knowledge base and an understanding of the main areas of science,  
   a. Have understood important concepts  
   b. Have developed scientific thinking and methods in working with data ...  
   c. Have developed a life-view which builds on an understanding of healthy individuals and responsibility in society;  
2. Have an overview of the role of science in culture and history;  
3. Understand the limitations of data;  
4. Engage in critical discussion of issues concerning nature, the environment and the relationship between science, technology and society; and  
5. Have sufficient self-confidence to use knowledge and skills for further studies, as an interest or at work.  
A written multiple choice national examination in science was reintroduced into the education system in the revised curriculum from 1999 after a break of twenty years and took effect in 2002.  
Schools are expected to adapt the national curriculum to their own situations, drawing on local settings where possible. Regular revision is expected. These processes are complex and require leadership and commitment at school and local level. They also require human resources in the form of well-educated committed teachers and practical arrangements for the teaching of science and innovation education/technology. Resources for science or technology teaching include:  
- Competent teachers  
  Of the 105 teachers in the 19 schools (or school units) which we visited fewer than five have specialised in teaching physics and chemistry. According to a recent survey by the Ministry of Education, Science and Culture, less than 40% have a specialised background in science, mostly in biology. Teacher self-confidence does however increase with experience and almost all teachers wanted further opportunities in learning how to teach science.  
- A school curriculum for science and technology  
  The school curriculum is usually updated annually but is only thoroughly revised at longer intervals, sometimes through dedicated projects. Sometimes it is reviewed according to age (e.g. younger children) and sometimes according to the subject. Sections of the national curriculum, especially excerpts from content areas, are copied into the school curriculum.  
- Facilities for teaching science, such as science classrooms, outdoor facilities, storage space, and the organisation of equipment and materials.  
The capacity of the science or technology teacher to teach science or technology is reflected in their teaching practices and in the learning opportunities created for learners inside and outside the school. These practices can be affected by the national or school curriculum and the resources available. They can also be affected by the knowledge, skills and sense of security or self-efficacy experienced by teachers and learners.  
Science is often taught in ordinary classrooms, starting with a short introduction by the teacher, perhaps a quick review of homework, or at least a check on whether it was done. Much of this classroom-based teaching and learning is driven by the textbooks available from the NECM developed both before and since the 1999 curriculum. Students often work alone or in small groups on assignments, many of which are found in their textbooks.  
In the older grades, homework assignments are most often based on questions and exercises in the textbooks. Occasionally older children have a longer assignment, such as a group project which might last several weeks. Younger children might be asked to read their books at home. Now and then some teachers require students to carry out some small practical exercises at home, a practice which some of their students regard as unfair. Most teachers and learners say that they would like to have more practical work, but in many cases the teachers appear to lack the self-confidence to carry out teaching of...
The curriculum revision from 2007 includes more emphasis on scientific literacy, in part related to Iceland’s participation in the PISA studies. The detailed objectives in the 1999 compulsory curriculum have been removed from the main body of the text and appear in an appendix and are expected to function as a bank of ideas for teachers. The content areas have been rewritten and, for example, now include more about the human body and a new cross-disciplinary topic “To live on earth” which allows for a discussion of sustainable development.

Some of the 1999 goals reappear in 2007, but goals 1.c and 5. have been replaced with the following goals. Students will at the end of compulsory school:

- Have the urge and interest to learn more about science
- Be familiar with manmade and natural environments, can move around them and can enjoy them by being outdoors
- Understand the relation between man and the environment and have developed a respect for nature
- Have developed a sense of responsibility towards sustainable development such that one’s lifestyle is compatible with it

The new laws on education from spring 2008 have removed the national examination in science from the 10th grade.

The 2007 approach, with new goals, less detail and no 10th grade examination, suggests that teachers and schools will have considerable leeway, and therefore much responsibility, for the way in which the school science curriculum is developed in compulsory and secondary schools.

The innovation education curriculum 1999 and 2007 sets goals in three areas: information and technological literacy, idea-solution-product and individual-technology-environment.

This kind. School facilities, including difficult storage and poor organisation, do not simplify or facilitate the task of teachers. In cases where such problems have been specifically addressed teachers carry out practical work but the quality of the lessons still depend to a large extent on teacher knowledge and skills.

Some teachers use theme-based approaches, particularly in the younger grades, which give children an opportunity to look at phenomena from several perspectives, e.g. agriculture, which might involve handwork, science, social studies, language work and a visit to a farm.

Outdoor education or teaching outdoors across the curriculum has gained popularity in recent years. Some schools have teachers who undertake outdoor work whatever the weather, but we also found schools where teachers did not seem to use outdoor opportunities which were on their very doorstep. In one district, all schools mentioned a three day field trip taken at the end of 7th grade as a good example of encouraging students to appreciate their environment.

Of the lessons we watched, only a few had a clear introduction, in which the purpose of the lesson or activity was communicated to students, and even fewer had a clear summary at the end.

Innovation education, which requires an identification of needs in the children’s own environment and a problem-solving approach by both teachers and learners, is seldom taught by science teachers when and if it is taught at all.
What influences student choice with regard to science and technology in secondary, further and/or higher education?

A recurring goal in science education is that students, when faced with a choice, will have the urge and interest to learn more about science. This awareness is reflected by the national authorities in the 2007 science curriculum in keeping with worrying trends related to school science and occupational choice. The average interest of 15 year old learners in learning science has been shown to be inversely related to the level of human development in the respective country. This has placed Iceland among the countries whose young people show the least interest in becoming involved with science related careers (Kristján Ketill Stefánsson, 2006). Young people also have expectations that are not met by the current job market (Ragnar F. Ólafsson og Almar M. Halldórsson, 2007). Roughly 10% of girls would like occupations in science, engineering or mathematics and between 15% to 20% of boys (p. 15). The number of boys wanting to be involved with computers dropped from about 20% to about 4% (p. 14).

Several factors have been found by researchers (OECD PISA, 2005) in Western countries to be important regarding the urge and the interest to learn more about science. The following factors were found to be especially important for Icelandic students (Almar Halldórsson og Kristján Ketill Stefánsson, 2007):

- Perceptions of learners with regard to activity stereotypes, gender roles, task demands and the beliefs of socializers
- The student’s self concept of ability in science
- The usefulness of science and technology for a future occupation
- Enjoyment of science
- Personal value of science

The relative importance of the usefulness of school science for future occupations highlights the importance of linking school science to possible careers by helping learners to adjust their perceptions and develop their interest and urge to learn more (Almar Halldórsson og Kristján Ketill Stefánsson, 2007). Sif Einarsdóttir has collected data in Iceland in her study of interests and future occupations that shows that upper secondary students can differentiate clearly between a preference for working with people vs. working with things. The distinction between working with data (gögn) vs. working with ideas is not as clear. These are interesting results if attempts are being made to increase the interest of young people in science. Of the 28 different fields science careers were ranked in the 18th position. Gender differences were low. Vocational preferences are mainly in artistic and social work environments and to a much lesser extent in conventional and realistic work environments.

Learners interviewed in the IR study perceived science related careers as related to things rather than people and did not associate science related careers with desirable work environments. When faced with questions regarding school science and science & technology related occupation the learners revealed limited experience and stereotypic perceptions. The learners indicated that they wanted their lives, including their future occupation, to be fun and meaningful. The current image of science and technology does not transmit this message to the learners (Kristján Ketill Stefánsson, 2006). Further analysis of the interviews is still in progress.

The implications of these findings for science education are important. Student choice will be influenced by their own experiences in science education (value, enjoyment and self-concept) as well as their perceptions of science in society (stereotypes, gender roles) and the perceived usefulness of science or technology for further study or a future occupation. A wide range of issues, inside and outside school, need to be addressed if if young people are to choose science more often as an option than they do now.
1.4 Conclusions and discussions

As noted above the main research question was:

What is the nature of the gap between the intended curriculum and the actual curriculum in school science and technology – the intentions and the reality?

The 1999 Icelandic national science curriculum had goals in three areas: conceptual understanding (content), procedural understanding (methods and skills) and learning about the nature and role of science and technology (sometimes known as NOS) in the literature. School science and innovation education share the goal of ‘doing’ something as a part of learning – making observations, for example, or making an object to solve a problem. Ideally conceptual and procedural understanding are developed together. Also, such understandings could be enhanced by considering some of the relationships between man and nature, and the nature and role of science and technology, their benefits and limitations.

All the above goals require however well-designed teaching sequences in appropriate educational settings in order for learning opportunities in keeping with the national curriculum to be created and used. Teachers are professionals who have a commitment to their profession and to their students (Strike and Soltis, 1985). Teaching is an emotional task where identity and motivation (Roth, 2007) play important roles. Not many teachers of science in Icelandic schools are trained as science teachers and are often asked by the principal to teach science, perhaps in late August, because no qualified teacher has been found and the principal considers them to have a related background, such as social studies or mathematics or nursing.

In the school visits there were many instances in which teachers referred to their background and training as being inadequate for teaching science. Teachers seemed to be unhappy – they felt that students were not getting the best possible teaching. ‘Practical work’ was most frequently identified by teachers and learners in the interviews as a key element missing from science classrooms. Practical lessons make considerable demands on teachers and learners with regard to management skills as well as content knowledge, an understanding of the nature of science and practical competence. Using practical work as a part of a teaching sequence is not a simple task. There is also the danger that the critical role of the teacher when using practical work could be underestimated and indeed there are occasions when teacher competence is extended beyond its limits and learners might miss the point altogether (Hipkins et al., 2002. p. 146-149). There is a gap between the intentions of the national curriculum and the capacity of teachers to implement them; not all learners are able to experience practical work and the development of related conceptual knowledge in the hands of a competent teacher.

But the ‘gap’ might work both ways. It is not only important to assess what parts of the national curriculum are and are not being assessed but also to understand what sort of science curriculum is de facto in place. Bell (2005, p. 165) has pointed out that the results of the Learning in Science Project (LISP) research in New Zealand showed “not only how the science content in part shapes the teaching and learning processes… but also how the pedagogy and learning processes shape the content learnt.”

Science is being taught in Icelandic schools and classrooms, according to the timetable and according to the number of hours or minutes required by the Ministry of Education, Science and Culture. What pedagogy is found? What learning processes are being encouraged in the actual curriculum?

Textbooks are of paramount importance and have much to say about the way science is and could be taught. The NCEM books are aligned with most of the content areas in the national curriculum from 1999 and in the teaching guidelines advice is provided on the planning of lessons, practical work and some additional information provided. Students need a certain type and level of literacy in order to access science in general and textbook science. Sometimes their teachers have not necessarily reached a high level of “science literacy” themselves, as they are only too willing to admit. Some teachers in the younger and middle grades read the textbooks for the 8th-10th grades as background material for their own teaching and are reluctant to teach certain topics, such as sound.

What are learners actually doing in their timetabled science lessons? They are very often reading and writing, but also listening and talking. Learners are supposed to read their textbooks at home and at school, sometimes even aloud, and they write answers to the questions in the textbooks. Learners may talk to each other about science in some exercises requiring group work, which for some of the time may not be used imaginatively or in a challenging way by teachers. Class discussions will depend on the extent to which teachers themselves feel comfortable with the topic under study. Investigative work in science or in innovation education, which offer open-ended solutions, is not very popular in Icelandic schools.
In PISA 2006 15 year old students were tested in three areas of science:

- identifying scientific issues,
- explaining scientific phenomena and
- using scientific evidence.

Students also completed questionnaires on their interests.

The average science performance in Iceland was below the OECD average. Icelandic students performed best in geology and astronomy where performance was on or above the OECD average. In Iceland girls were better than boys at identifying scientific issues and in biology and ecology while boys were better in geology, astronomy, physics and chemistry (Almar M. Halldórsson, Ragnar F. Ólafsson and Júlíus K. Björnsson, 2007).

The level of interaction in classrooms, linking science to daily life and to its future usefulness could explain less than 1%, 3% and 6% of performance respectively. But student self-image (highly correlated with self-efficacy) could explain 23%, enjoyment of science 22% and feeling responsible towards resources and the environment 23% of performance.

In 1992 the Ministry carried out a survey of science performance and the attitudes of teachers, in which 92% of 5th grade teachers (N=80) ranked “encouraging conservation of nature and the environment” as a very important aim of science teaching but this dropped to 69% among 9th grade teachers (N=103) along with “preparing students for life”. A slightly more important aim for 9th grade teachers (72%) was more cognitive, i.e. that “students should understand interconnections in nature” (Macdonald, 1993b).

These two sets of results, on what explains performance and the aims which teachers have, if taken together, tell us that science learning is very much a question of motivation. If there is a value or a reason for knowing something, students will learn. If students feel confident and are enjoying themselves, they will learn.

These values may be promoted or the reasons better understood in the hands of competent committed teachers. It looks as if the ‘gap’ could be bridged by teachers having more science knowledge and better skills for teaching science. It looks however as if others in society and not just teachers also need to take responsibility for the views of science which prevail.

The gap is in fact a space in which stakeholders wrestle for power, a space in which the curriculum is constructed (Figure 1.1). Into this space policy-makers put forward the national curriculum and teachers put forward their skills and knowledge. But others also have a say, as was clear from the IR study. Learners themselves can affect the curriculum, principals and local authorities can support science or not depending on their leadership and management and books and digital resources can also play a part. The space is a heavily contested area, and each and every stakeholder is affected by the views on science held by the economy and by society. Behind the policy makers and the local authorities are all kinds of issues. Teacher education is important. Opportunities for young people inside and outside school make a difference.

![Figure 1.1 The way in which the curriculum is being constructed](image-url)
References


Intentions and reality in science and technology education in Iceland

Project funded by the Research Fund of Iceland 2005-2007

Publications
Reports
Presentations
Papers

December 2008
Introduction

This document contains a list of the reports written on school visits and other studies in the IR project. All conference presentations are also to be find here. Finally there is a list of other publications, including journal articles in preparation.

Reports

Those involved in the project have visited schools in teams and written up short reports on the conditions for science teaching, support given to the teachers and the skills and self-confidence of teachers. Summary reports have also been written for all schools in a district.

Science education in selected Icelandic schools

All reports are available at http://starfsfolk.khi.is/kristjan/vv

Fljótsdalshérað


Samantektarskýrsla: Náttúrafræðimenntun á Fljótsdalshéraði. Haust 2006
Allyson Macdonald (2007)

Auður Pálsdóttir, Björg Pétursdóttir and Meyvant Þórólfsson (2007)

Fjarðabyggð

Kristján Ketill Stefánsson og Meyvant Þórólfsson (2006)

Meyvant Þórólfsson og Svanborg Rannveig Jónsdóttir (2006)

Auður Pálsdóttir og Haðór Guðjónsson (2006)

Náttúrafræðimenntun á Austurlandi. Haust 2006. Skýrsla 8: Grunnskóli Fáskrúðsfjarðar


Samantektarskýsla: Náttúrafræðimenntun í Fjarðabyggð. Haust 2006
Meyvant Þórólfsson (2007)

Garðabær

Kristján Ketill Stefánsson og Svanborg Rannveig Jónsdóttir (2007)

Náttúrafræðimenntun í Garðabæ. Skýrsla 2: Hofstastaðaskóli
Allyson Macdonald og Meyvant Þórólfssson (2007)

Náttúrafræðimenntun í Garðabæ. Skýrsla 3: Sjálvlandskóli
Auður Pálsson og Stefán Bergmann (2007)

Auður Pálsson (2007)

Snæfellsnes


Breiðholt

Svanborg R. Jónsdóttir, Eggert Lárusson, Stefán Bergmann og Hrefna Sigurjónsdóttir (2007)


Innovation education

Svanborg R. Jónsdóttir (2007)

http://www2.hi.is/Apps/WebObjects/HI.woa/swdocument/1013012/Svanborg_analysis.pdf
Short report for general distribution


Reports in preparation

Self-evaluation of science in selected Icelandic schools.

Björg Pétursdóttir, Haukur Arason and Auður Pálsdóttir. (2009)

Conference presentations

In Icelandic


In English and/or abroad


Conference proposals 2009

ASE, Bretlandi
Two proposals were accepted for presentation at the Association of Science Education (ASE) Annual Conference to be held in Reading, England, January 2009.


NARST, Bandaríkjunum
Two proposals were accepted for presentation at the Annual Conference of the National Association of Research on Science Teaching, to be held in California, USA, April 2009.


Articles

Published


*In preparation*

Björg Pétursdóttir. *Upplifun nemenda á háopavinnu í framhaldsskóla*. Accepted with revisions.


Kristján Ketill Stefánsson, Sif Einarsdóttir and Allyson Macdonald. Motivation and interest in science of young Icelanders.

**Workshops/seminars 2007**


Intentions and reality: science and technology education in Iceland

Final report
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Part 2
Work plan – evaluation
Outcomes
Use of results
Impact

Allyson Macdonald
Project leader
2.1 Introduction – the context

Peter Fensham, a noted science education researcher in Australia, has written about the development of a research identity in the field of science education (Figure 1). The project *Intention and reality: science and technology education in Iceland* (IR project) started at about the same time that the Science Education Research Group (SERG) was established at the Iceland University of Education (IUE) and many of the members of SERG have taken part in the project. Thus the implementation of the project should be placed in the larger context here in Iceland with members of SERG and participants in the IR project being committed on several fronts. Some of the key events requiring contributions from participants in recent years are summarised in Appendix 1. Particular attention was paid to creating a space for discussions on science education. Two national and one international conference has been held in the last three years.

![Developing a research identity - criteria](image)

*Figure 2.1* Developing a research identity (from Fensham, 2004)

Participants in the project are listed below.

<table>
<thead>
<tr>
<th>Participation</th>
<th>AM</th>
<th>AP</th>
<th>BP</th>
<th>EBK</th>
<th>EL</th>
<th>HA</th>
<th>HG</th>
<th>HS</th>
<th>KKS</th>
<th>MP</th>
<th>SB</th>
<th>SRJ</th>
<th>HH</th>
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<tbody>
<tr>
<td>Dr Allyson Macdonald professor/project leader</td>
<td>Auður Pálsdóttir adjunct/specialist</td>
<td>Björg Pétursdóttir specialist</td>
<td>Elin Bergmann Kristinsdóttir student/assistant</td>
<td>Dr Eggert Lárusson lecturer</td>
<td>Dr Haukur Arason lecturer</td>
<td>Dr Hafró Guðjónsson senior lecturer</td>
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<td>Meyvant Pórólfsson lecturer</td>
<td>Stefán Bergmann senior lecturer</td>
<td>Svanborg Rannveig Jónsdóttir student/assistant</td>
<td>Hrafnhildur Pórólfsdóttir assistant</td>
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</table>
AP joined the project in August 2006 when she was employed as an adjunct at the IUE. She has recently started her doctoral studies. BP has worked with the project from 2006. EBK was a graduate student who worked with the project until mid-2007 when she withdrew for personal reasons. KKS joined the project as an assistant while completing his master’s research at the University of Oslo and is now an adjunct and in the doctoral program. SRJ joined the project when she began her doctoral studies in mid-2006 on innovation education, which is closely related to technology education as it is taught in countries such as New Zealand and Canada. HP worked with the project as an assistant, mainly in 2007. Almar Halldórsson (Námsmatsstofnun) and Sif Einarsdóttir (University of Iceland) have worked with project participants on some issues.

2.2 The research perspective – theory and approach

At the outset of the study data collection was planned in the following six areas in order to answer the research questions (Table 2.1). The project was introduced to colleagues in SERG and to graduate students and expressions of interest obtained.

Table 2.1 Planned data collection

<table>
<thead>
<tr>
<th>1. Analysis of national curriculum</th>
<th>4. Analyses of school curricula</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Data from comparative international studies</td>
<td>5. Views of teachers and learners</td>
</tr>
<tr>
<td>3. Needs of the labour market</td>
<td>6. Classroom observations</td>
</tr>
</tbody>
</table>

The project started with the apparently simple assumption that there was a gap between the intentions in the national curriculum and the actual curriculum experienced by children and the question was to find out more about the nature of the gap. The intended curriculum is in part determined by social and economic forces and the actual curriculum by the teaching and learning experiences in the classroom. As the study proceeded individual researchers began to make their contributions to different parts of the IR project. As might be expected there were a range of views in the group on the approaches to be used and the theoretical understandings to be gained. Curriculum theory is an ever-growing field and there are many ways to approach research on the curriculum.

The project leader has been working for several years with theories from cultural-historical activity theory and the sociological theory of education developed by Basil Bernstein (Bernstein 1996/2000, Daniels 2004, Engeström 1987, Morais 2002). These theories have become a part of the way in which some participants analyse and interpret the data (AM, AP, SRJ). Another (KKS) has been deepening his understanding of theories of motivation as proposed by Bandura (Bandura, 1989, 1997; Schunk, Pintrich, & Meece, 2008) and is using these theories to look at data from and about learners, both from interviews and comparative studies. MP approaches the development of the science curriculum in Iceland from a historical point of view.

In mid-2006 the project leader was asked to give a talk in Scotland on the Icelandic science curriculum in March 2007. The data collection during 2006-2007 was in part guided by the framework shown in Figure 2.1. The main voices to be considered were those of policy makers (the intended curriculum) and those of teachers who taught the ‘actual curriculum’, an approach which had been used in the NámUST project (Allyson Macdonald and Pórstéinn Hjartarson, 2004). We would also search for and listen to other voices.
Thus in our data collection in schools we were interested in hearing from teachers, principals and learners in order to understand the in-school construction of the school curriculum. In some districts we have spoken at length to local authorities and indeed, one doctoral study will address science teaching in one local authority, building on the results of the IR project. A study on textbooks is underway and a preliminary results were presented in June 2008. MP is writing his doctoral thesis on the development of the science curriculum in Iceland since the mid-20th century and will pursue a diachronic view of curriculum studies.

**References**


2.3 Work plans

The initial work plan for the project is in Table 2.1. By the end of the project period some of these components (b, d, e) were satisfactory, while others (a, c) were still in progress. Work has continued in all areas in 2008. Component f is the least satisfactory. All components are discussed in more detail below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a Analyses of the national curriculum</td>
<td>Literature survey Analysis of texts</td>
<td>Draft reports for discussion</td>
<td>Final reports and journal article</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b Further analysis of data available from comparative education studies</td>
<td>Selection and preparation of data Preliminary analysis</td>
<td>Refining of data and further analysis</td>
<td>Draft reports for discussion</td>
<td>Final reports and journal article and/or thesis</td>
<td></td>
</tr>
<tr>
<td>c Analysis of the needs of the labour market</td>
<td>Consultation with other researchers Selection and trialling of techniques</td>
<td>Further trialling of techniques Analysis</td>
<td>Draft reports for discussion</td>
<td>Final reports and journal article and/or thesis</td>
<td></td>
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<tr>
<td>d Analyses of school curricula</td>
<td>Selection of sub-sample Preliminary analysis, trialling of techniques</td>
<td>Further trialling of techniques Analysis</td>
<td>Draft reports for discussion</td>
<td>Final reports and journal article and/or thesis</td>
<td></td>
</tr>
<tr>
<td>e The views of students and teachers on the existing curriculum</td>
<td>Literature survey Preliminary analysis, trialling of techniques</td>
<td>Data collection Analysis</td>
<td>Draft reports for discussion Draft of thesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f Classroom observations of science and technology education</td>
<td>Literature survey Preliminary analysis, trialling of techniques</td>
<td>Data collection Analysis</td>
<td>Draft reports for discussion Draft of thesis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Analyses of the national curriculum (NC)**

At the outset of the study a preliminary analysis of the 1999 national curriculum (NC) was available based on a study in 2002 (AM) and a conference talk in 2005 (AM in New Zealand). This used the seven-frame model developed by AM. MP had in 2004 identified the development of NC as a key area of interest for his doctoral studies and has written up an analysis of the 1999 national curriculum and another policy document (Even better schools) from 1999. The NC was also a theme in the research on teachers’ use of ICT (MP, AM and EL). SB has considered changes in the biology and environmental education curriculum over the last thirty years (SB).

The NC underwent extensive revision in 2006/2007 and HG and BP were actively involved. A seminar on the role of the NC was held in March 2007 at which both AM and BP made presentations. The revised NC was approved in spring 2007 and we have not yet subjected the 2007 NC to detailed analysis but it is clear that it will make different demands on learners and teachers than the 1999 NC. The 1999 NC is valid until 2010 by which schools should have adjusted to the 2007 NC. One outcome of this project could be to facilitate discussions among teachers on the new curriculum.
AM carried out a study of the way in which so-called “neighbouring activities” affect the central activity of science education. The core of the data was official public discourse from Scotland and Iceland, but there were also European connections. Official documents about science teaching, science communication and science for the public were analysed for the messages which they send schools and teachers on what kind of science education is desirable. This analysis was presented at two conferences, in Oslo (2007) and in Reykjavík (2008). It is such discourse which creates in part the base upon which a national curriculum is founded. This paper will be prepared for publication in 2009.

- **Further analysis of data available from comparative education studies**

Early in the study EBK expressed interest in working with the PISA data and in 2006 she attended a PISA workshop on data analysis. We were also interested in looking at PISA results in other small countries such as Scotland, Ireland and New Zealand, and EBK began that work. For personal reasons, EBK had to leave the project and this line of development was not pursued.

However, a parallel development was cooperation between SERG member and National Testing Institute (NTI) staff, who carry the responsibility for PISA in Iceland. SB and AM have been advisors on the science component of PISA since 1998. Almar Halldórsson from the NTI held a seminar on PISA with SERG in 2006 and in late 2007 a series of working meetings with SERG were held at the request of Almar as part of the preparation of the Icelandic report on PISA 2006.

A close working relationship developed between Almar and KKS and together they presented a paper on PISA 2006 results at an European conference in August 2007, in which they used PISA data to consider the characteristics of learners who took the 2006 national examination in science or not.

- **Analysis of the needs of the labour market**

At the beginning of this study some data collected by Sif Einarsdóttir at the University of Iceland gave some interesting clues on what the work interests of young people were. This data and other ideas on interest and motivation have been discussed at several project meetings (see below under views of learners). EBK had begun a summary and analysis of data from Statistics Iceland on the labour market, but this was not continued when she left the project.

AM, through her participation in an Icelandic workgroup in the European project, Education 2010, was able to access figures on the apparent needs of the research market, and the emphasis being laid on science and technology education in lower and upper secondary school was highly apparent in visits to Holland and Norway as part of an European Peer Learning Activity.

SRJ undertook a study on enterprise education (frumkvöðlamennt) in secondary schools in Iceland as part of a Leonardo project and has presented interesting information on the opportunities available in secondary schools for relating technology to business.

This part of the study has however little else by way of reports or presentations.

- **Analyses of school curricula**

Schools are required by law to prepare a school curriculum, in which it is expected that the national curriculum is adapted to local circumstances. Initially (spring 2005) selected compulsory and secondary school curricula available on school web-sites were subjected to analysis using the seven-frame model (BP, KKS, MP, AM). We soon found that there was a great variation among these curricula and that we would not know much until we got into schools.

During the winter of 2006-2007 researchers went in pairs or small groups to schools in five areas of Iceland:
- Fljótshalshérað (four compulsory schools and one secondary school)
These visits involved everyone listed as a participant in the project, and individual reports have been written on the visits to all compulsory schools, four summary reports for four of the five districts and on two of the secondary schools.

The preparation of the school visits took several months – and included identifying/selecting the districts we would visit (AM, MÞ, BP), making initial phone-calls to principals and science teachers to gather preliminary data (MP, BP), preparing the electronic questionnaire SCIQ (see next section) (MP, AM, EL, KKS, EBK), preparing interview protocols (AM, MP, KKS) (see next section), checklists for classroom observation (HG) and a checklist on school facilities (MP). The final arrangements for the visit to the east of Iceland were made by MÞ and KKS. We were fortunate that AP and SRJ joined the project at this time; AP had an interest in self-evaluation and SRJ was starting her research on innovation education, which is closely related to technology education as taught in other countries.

Each visit took one day during which interviews were taken with the principal, teachers (singly, in pairs or in groups) and older learners, and the school facilities toured and photographs taken. Prior to the visit teachers in compulsory schools answered the SCIQ (see below). After the visit drafts of reports were prepared and sent to the schools for review before being completed.

All reports on compulsory schools have been written, one secondary report has been completed, another is almost complete and a third exists in draft form (every participant has co-written at least one report).

- The views of students and teachers on the existing curriculum

Teacher views were assessed by SCIQ and by interviews.

SCIQ is the Science Curriculum Implementation Questionnaire and was developed by Brian Lewthwaite as part of his doctoral research in New Zealand. He is now based at the University of Manitoba where AM visited him in October 2005. We obtained permission to translate and adapt the questionnaire which we did in the school year 2005-2006 with grants from the Research Fund and Assistant’s Fund at the Iceland University of Education. We used the same methodology as was used in the European Social Survey, i.e. two separate translations are prepared, a third person goes over these and makes suggestions for wording where the translations differ and a fourth person makes the final decision (AM, EBK, EL, KKS, MP). The first version was trialled in two schools and the list reduced from 49 to 35 questions on the actual delivery of science and 35 on the preferred delivery of science. An electronic version was then prepared (KKS) linked to a database where results could be analysed using SPSS. SRJ prepared a similar questionnaire on innovation education. Results are available from 105 teachers from the school year 2006-2007.

Questions in SCIQ can be sorted into five groups:
- Time available for teaching
- Resources available
- School ethos with regard to science
- Professional support for science teachers
- Knowledge, skills and self-confidence of teachers

The main results of the assessment of teacher views (SCIQ and interviews) the first three districts visited were presented at the Biannual Conference of the European Science Educational Research Association (ESERA) in August 2007 in Malmö. A full paper was published in the proceedings,
distributed on disk at the conference. A report detailing the development of the Iceland SCIQ and an analysis of the main results is under preparation (AM, AP).

Interview protocols for interviews with teachers and learners were developed (AM, MP, KKS and others), and then revised by the IR group at work meetings. Where possible the interviews were taken by pairs of researchers, but this was not always a practical use of time. All the interviews (over 120) were recorded on small digital recorders but in a few cases the recordings failed. Transcription of the recordings began in spring 2007 but has proceeded slowly, for several reasons. Nearly all the interviews with learners have been transcribed. Not all the interviewers were skilled at taking interviews. Some of the interviews are group interviews and are difficult to transcribe. Some recordings are of a poor quality – they were all taken on site in schools and the rooms available were variable in quality. The rate at which transcriptions have been produced is too slow and has proved expensive for the amount produced. The project has used six transcribers some of whom just faded away without producing much, perhaps because of a lack of interest and the availability of other work. The transcription has achieved some momentum in Autumn 2008 and we hope that it will be finished by early 2009, though we may not have enough funds for the entire batch.

A journal paper is being prepared by KKS, AM and Sif Einarsdóttir on the views of learners, based on the interviews with learners, PISA data and according to a theoretical framework developed by Bandura.

Several project participants (for example, AM, AP, KKS, MP, SRJ) will use the transcripts of interviews with teachers in different studies – on self-evaluation, on science in a particular district, on science teaching at different levels (younger, middle school, lower secondary, upper secondary) and on the relationship between the national and the school curriculum – i.e. the voices of teachers.

- Classroom observations of science and technology education

In the preparation for the school visits, it was decided that researchers would observe in pairs, one using a structure checklist developed by HG and based on experiences with student teachers and the other doing an open-ended written recording of what was happening in the classroom. It was also hoped that some researchers would at some point be able to take videos of lessons and analyse the content and development of lessons.

This component is however the weakest of all, for a variety of reasons. It proved difficult to watch lessons in pairs. Some teachers did not want us to observe their lessons. The school visits were sometimes too short or too crowded for any observation of lessons, possibly even a mutual reluctance on the part of researchers and teachers, as classroom observation is not a widely used research method in Iceland.

Most lessons that were observed have been described in the reports written on the school visits. Three of us (AM, AP and EL) are in the process of eliciting more detailed descriptions from researchers of the lessons observed.

In many of the interviews and observations, the role of the text-book in planning and teaching science was clear. A preliminary study has been carried out on a textbook series used in the middle grades (5th to 7th) and a proposal has been submitted to the Research Fund at the University of Iceland for a follow-up study which will incorporate observations of lessons in which the books are being used.
2.4 Outcomes

The project has led to several outcomes:

- Reports on school science in over 20 schools. The reports include the results of self-evaluation and outsider evaluation on the provision of science.

- Presentations arising from the project have been made at national and international conferences (in Iceland, Scotland, Sweden, Norway and England) and for a student group in Canada.

- The results of the SCIQ and the interviews with teachers provide a base with which to work with teachers in schools.

- The results of the interviews with learners have helped in the interpretation of numerical data from PISA on student interests.

- Some members of the Science Education Research Group (SERG) have got to know each other better, exchanged opinions and experiences and worked on reports or presentations.

- Early on two master’s theses (BP, KKS) were completed on topics related to the project. Although these projects had started before the IR project, they were associated with the project in their final stages.

- The work in Garðabær was carried out as part of a project on providing advice to science teachers in schools, so the initial evaluation was followed up with further work with teachers.

- Four doctoral projects are associated with the project (MP, KKS, SRJ and AP).

- The work on innovation education in Icelandic schools (SRJ) has led to a much better understanding of what it involves and how it can be related to science education.

- AP will carry out work on ways of improving science teaching through coaching and mentoring in a rural district.

- New ways are emerging of understanding how textbooks are produced and used and the underlying messages of science in them.

- Several of the project participants have used the IR experience in a related project on education for sustainable development.
2.5 Use of results and impact

Science education in Iceland stands at a crossroads:

- The new laws on education make change in secondary schools imperative. There will be an emphasis on competences. What does this mean for science?

- A revised science curriculum for compulsory schools was issued in 2007 to be implemented by 2010. Schools and teachers are already responding to some of the demands of the new curriculum. These changes require competent self-confident teachers. The IR project has shown that many teachers lack self-confidence and feel that they need more background in science and training in science teaching.

- The methods developed by the IR project offer opportunities for self-evaluation in subject areas and program planning in schools. These methods could be made into a ‘product’ which could secure a modest income for further research.

- The science textbooks which have been used for the last 12-15 years in lower secondary school will not be reprinted and some are already out of print. Digital learning resources are not very visible in science education. Important decisions must be made in this area.

- The national examination in science, usually taken by 15 year old students in the 10th grade, will no longer be offered. What ‘lessons’ have we learnt from the IR project to help schools plan the science and technology options they will provide to students?

- There are opportunities for more informal science learning and learning out of school. Science and technology for the public can play a role in reaching young people. During the last few years several of the IR participants have been involved with feasibility projects to establish science and/or technology learning centres.

- There is an urgent need to increase the number of inservice opportunities in science and innovation education, to increase the number of preservice students in science education and to offer innovation education in preservice training.

- More informal inservice opportunities can be made available through workshops and conferences which require only short periods of commitment from teachers. The two national conferences held in 2006 and 2008 were well-attended by Icelandic teachers. Here too digital learning resources could play a role.

All of the above require a coordinated effort to disseminate the results of the IR project, especially but not only in Iceland, and to discuss the implications of the findings for further development of science and innovation in schools.
2.6 Conclusions

The IR project has had some successes and some dead-ends. It has been carried out during a phase of rapid change in Icelandic society and in education.

The research identity of the participants in the project (Figure 2.1) has come under scrutiny more than once, especially when choices have to be made between working on further research or working on ways to have an effect on practice. There is a real dilemma here which has not been resolved.

This was a difficult project to manage intertwined as it was with some of the goals and activities of SERG. Early on an internet workspace for project participants was created and all interviews (both sound files and transcriptions) were placed there, as well as reports, presentations, web-links and other related materials.

In autumn 2005 the project leader began to look for students who wished to participate in the project and for colleagues who wished to contribute. Whole and half day meetings were held at regular intervals all 2006 and 2007. Discussions were intense but it was sometimes difficult to reach decisions, or follow-up on decisions made at meetings was sometimes poor.

The strength of the project has been in the very active participation of graduate students and cooperation between doctoral students and the project leader.

A weakness on the other hand was that the participation of academic colleagues (staff) was less limited than envisaged. This can be attributed to several factors. One is that there is little experience of working as a team and the interests and strengths of staff are very broad and not necessarily those being researched in the IR project. Another is that for much of the academic year 2007-2008 several members of SERG (and participants in the IR project) were involved in preparations for the Nordic Symposium on Research in Science Education held in Reykjavík in June 2008. Finally during the periods 2005-2008 the IUE was revising its courses of study for teacher education (2005-2007) and preparing for the merger with UI. Academic staff at the IUE had heavy workloads.

An opportunity for the project participants in 2009 is to become familiar with the results emerging and to engage each other and schools in discussion about what might be done in science education. A threat, as always, will be the demand for advisory services, committee work and other project initiatives that call on individuals rather the IR or the SERG group.
Intentions and reality: science and technology education in Iceland

Final report
Submitted to the Research Fund of Iceland
December 2008

Part 3
Funding and expenses

Allyson Macdonald
Project leader
### 3.1 Accounts

**Table 3.1** Summary of funding and expenses in the project

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**HEILDARKOSTNAÐUR:**

| 8462200 | 10643080 | 7592000 | 7977563 |

minus stjórnunargjöld er 717500

**Fjármögnun 2)**

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**Álls** 7592000

Frá styrkþega(uum): HA 20000

7612000

Fjármögnun des 2008 7612000

Ósk um lokagreiðslu úr 748000

Rannsóknasjóði að upphæð: 8360000

HEILDARFJÁRMÖGNUN: 8360000
3.2 Researchers, students and assistants

The staffing of the project is shown in Table 3.2, 3.3 and 3.4.

### Table 3.1 University staff

<table>
<thead>
<tr>
<th>Participation</th>
<th>Name</th>
<th>Status</th>
<th>Project role and activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>Dr Allyson Macdonald</td>
<td>Professor</td>
<td>Project leader, 40% research, sabbatical Autumn 2005, and 6 weeks Autumn 2008</td>
</tr>
<tr>
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<td>25% research and university administration from Autumn 2006, school visits and reports, views of teachers SCIQ</td>
</tr>
<tr>
<td>AP</td>
<td>Auður Pálsdóttir</td>
<td>Adjunct 2006</td>
<td></td>
</tr>
<tr>
<td>EL</td>
<td>Dr Eggert Lárusson</td>
<td>Lecturer</td>
<td>School visits and reports, views of teachers SCIQ</td>
</tr>
<tr>
<td>HA</td>
<td>Dr Haukur Arason</td>
<td>Lecturer</td>
<td>School visits and reports, views of students</td>
</tr>
<tr>
<td>HG</td>
<td>Dr Hafþór Guðjónsson</td>
<td>Senior lecturer</td>
<td>School visits and reports</td>
</tr>
<tr>
<td>HS</td>
<td>Dr Hrefna Sigurjónsdóttir</td>
<td>Professor</td>
<td>School visits and reports</td>
</tr>
<tr>
<td>KKS</td>
<td>Kristján Ketill Stefánsson</td>
<td>Adjunct 2008</td>
<td>25% research and university administration from Autumn 2008</td>
</tr>
<tr>
<td>MP</td>
<td>Meyvant Þórolfsson</td>
<td>Lecturer</td>
<td>Sabbatical Spring 2007, school visits and reports, curriculum analysis, views of teachers SCIQ</td>
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<tr>
<td>SB</td>
<td>Stefán Bergmann</td>
<td>Senior lecturer</td>
<td>School visits and reports</td>
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### Table 3.2 Doctoral students

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<td>MP</td>
<td>Since 2004</td>
<td>The development of the national curriculum</td>
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<td>KKS</td>
<td>Autumn 2006, leave, Autumn 2008</td>
<td>Interest and motivation of young people in choice of science-related occupations</td>
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<tr>
<td>SRJ</td>
<td>Autumn 2006</td>
<td>Locating innovation education in Icelandic schools</td>
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### Table 3.3 Specialists/assistants

<table>
<thead>
<tr>
<th>Participation</th>
<th>Contribution</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>BP</td>
<td>Björg Pétursdottir</td>
<td>Student/specialist; school visits, reports, analysis of curriculum</td>
</tr>
<tr>
<td>EBK</td>
<td>Elín Bergmann Kristinsdóttir</td>
<td>Student/assistant, SCIQ, comparative data</td>
</tr>
<tr>
<td>KKS</td>
<td>Kristján Ketill Stefánsson</td>
<td>Student/assistant/specialist Views of teachers and students SCIQ Comparative data</td>
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<tr>
<td>SRJ</td>
<td>Svanborg Rannveig Jónsdóttir</td>
<td>Student/assistant/specialist Innovation education, views of teachers and students, classroom observation</td>
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<tr>
<td>HP</td>
<td>Hrafnhildur Þórólfsdóttir</td>
<td>Assistant Coordination and editing</td>
</tr>
<tr>
<td>Other Transcribers</td>
<td>Assistants Transcriptions of</td>
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</tr>
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</table>

### 3.3 Explanation of accounts

On the whole spending in the project has been within the budget (Table 3.1), though with two deviations.

In the original project proposal, it was expected that we would pay for most project assistance through sub-contracting to specialists (see the original budget in Appendix 2). According to the modified budget we expected to pay 6.535 m.kr. under this budget line but only BP and some transcribers wanted to be paid as sub-contractors, and the rest preferred to be on a fixed salary for a few months at a time. Thus the accounts show that 1.270 m.kr. was paid to sub-contractors and 5.540 m.kr. as salaries to specialists/assistants, giving a total of 6.810 m.kr. for project assistance.

We request the research fund to accept this submission. The Iceland University of Education provided office space for the doctoral students/specialists, for example, to KKS and SRJ, as well as for HP, and on the same floor in Bolholt 6 as AM, AP and MP. This provided the project with a much stronger nucleus and easier communication.

We have printed all the reports on school visits for distribution to participating schools. Some of these expenses (150 þ.kr.) have appeared under perishables (rekstrarvörur) and some under other specialist assistance (önnur sérfærðiþjónusta). Some small amounts were spent on refreshments during the longer project meetings.

The funds remaining (748 þ.kr.), if paid in, will cover the current deficit of 341 þ.kr., administrative costs of 134 þ.kr. and transcription costs of 275 þ.kr., which however will not cover all remaining costs of transcriptions.