Abstract
Science textbooks play an important part in school science in Iceland, as in many other countries. This research is one study in a larger science education research and development project currently being carried out in Iceland. This study is designed to gain an understanding of the way in which a science textbook developed for a specific context might influence the ‘science story’ being told to young learners. A revised national curriculum was published in Iceland in 1999. A series of three textbooks and teacher guides titled Auðvitað (Of course!) and written for the middle school, grades 5 to 7 (ages 10-12), is being analysed. The Auðvitað books, published in 2000 and 2001 by the National Centre for Educational Materials, cover topics in physical and earth sciences. The materials are used each year in several hundred classrooms involving about 4000 or more learners per age group.

Preliminary results indicate that the text in the chapters selected for analysis rests more on everyday knowledge than scientific knowledge. The text is presented in a relatively informal manner, given that it is from a science textbook, and the reader often has the responsibility of what to do with the main body of text being read. The overall message is that everybody can learn science! The visual images are generally realistic and the boundary line between what is everyday and what is scientific knowledge is blurred. Again the reader is left with the task of what to do with the image and the overall message to the learner is that science is not really amazing!

Aims and background
Aims
Science textbooks play an important part in school science in Iceland. In a small country resources must be used well and the science being taught in schools is of more than passing interest in a modern country which thrives on technology and change.

The purpose of this study is to analyse and understand the science ‘story’ told each year to middle school children in Iceland. The focus of the study is a series of textbooks and teacher guides called Auðvitað (e. Of course!) written for middle school grades 5 to 7 i.e. ages 10-12. There are about 4000-4500 children per year class in Iceland. The books cover topics in physics, chemistry and earth sciences and were published in 2001 and 2002 (Grímsson, 2001a, 2001b, 2001c, 2001d, 2002a, 2002b). The books are strongly aligned with the national curriculum from 1999. One (HG) of the researchers is the author of the books and the other two are curriculum researchers.

This research is one study in a larger science education research and development project currently being carried out in Iceland. The main research question guiding the study is:

1 The Intentions and reality project on science and technology education is being carried out by a team of researchers from the Iceland University of Education and was funded by the national Research Fund in Iceland from 2005-2007. This study also received funding from the Research Fund of the Iceland University of Education in 2007.
What is the nature of the gap between the intended curriculum and the actual curriculum – the intentions and the reality? Subsidiary questions include: What are the main features of the national curriculum in science in Iceland from 1999? What resources are available for science teaching and learning (particularly ICT) and what is their role? What learning and teaching practices are typically found in schools? What influences student choice with regard to science and technology in secondary, further and/or higher education?

**Background**

In the 1970s there were several major curriculum projects underway in Iceland, including the production of new materials for science teaching (Macdonald, 1993a). In the late 1960s and early 1970s eight units in physics and chemistry, based on student carrying out experimental work, were written for learners aged 10-12. The units were short and in the form of worksheets with questions to be answered by students. Guidelines for using the material were written for teachers and for a few years in the late 1970s inservice courses on using the materials were held around the country (Macdonald, 1993b). The use of scientific processes, such as measuring, observing and comparing, were encouraged in most of the units. All the units required preplanning with regard to apparatus and chemicals were required for two units. Over time use of the materials dwindled and by the late 1980s the most popular units were being used in less than 40% of rural schools and in from 36% to 64% of urban schools (Macdonald, 1993, p. 15).

Until 2007, when a new law was introduced (Act 71, March 28th 2007, the primary responsibility for the development of educational materials for compulsory schools in Iceland has been in the hands of the National Centre for Educational Materials (NCEM). The NCEM called for an evaluation of the physical science middle school materials in 1987 (Macdonald, 1987a, 1987b). In the mid-1990s it was decided to produce new science materials for lower secondary school and by the late 1990s it was clear that teachers would call for many new materials in order to teach the revised curriculum of 1999. The task of producing a series of books for middle school physical and earth sciences was put out to tender. Earth sciences were a new area in the science curriculum and overlapped in part with the geography curriculum. The materials were to be developed in close cooperation between the NCEM editor responsible for science and the author. The materials appear to have been well-received by many teachers and are used each year in several hundred classrooms involving about 4000 or more learners per age group.

This study is designed to gain an understanding of the way in which a science textbook developed for a specific context might influence the ‘science story’ being told to young learners. The books are analysed according to a scheme (hereafter DKS scheme) for textbook analysis developed in Greece by Dimopoulos, Koulaidis and Sklaveniti (2003, 2005). It also draws on an analysis of books as ‘cultural objects’ according to a scheme (hereafter the IMMG scheme) developed in Spain by Izquierdo, Marzabal, Marquez and Gouvea (2007). A key part of the latter scheme involves what is called ‘communicability’ in which the books are analysed in terms of the model of science, the model of the reader and the didactical model being proposed in the textbooks. A preliminary analysis of part of one textbook was then carried out in which two chapters (20 pages) have been analysed by the DKS scheme.

**Value and limitations of the study**

The use of curriculum materials varies between countries. Classroom observations in the schools in Iceland have shown that “teachers depend to an inordinate degree on the textbooks, for teaching methods as for content” (Ingvar Sigurgeirsson, 1993, p. 274;
Hafsteinn Karlsson, 2007). This study contributes to an understanding of the textbook itself.

This is a preliminary study of the role of the textbook in teaching and learning science. The intentions of the writers of the national curriculum have been recontextualised in the textbook in an activity which is guided by the intentions of the editor/publisher on the one hand and the writer on the other. What has happened in the recontextualisation? What views of science, teaching and learning are presented in the textbook? What influence might these views have on the use of the textbook by teachers?

In using the DKS criteria, some uncertainties arose because of language issues. The scheme was developed for an analysis of Greek textbooks and the results reported in English. In applying the scheme to Icelandic text certain problems arose which need further clarification and investigation. Finally there is a need to check intercoder reliability.

**Frameworks for analysing textbooks**

In the United States, the National Science Foundation (n.d.) has developed frameworks for the review of instructional materials for middle school science. These pay particular attention to the quality of the science presented in books and the pedagogical design but which also consider the use of the materials and system support that might be required. Project 2061 which is run by the AAAS (American Association for the Advance of Science, 2002) has also drawn attention to the quality of science textbooks. Categories used in the AAAS scheme for the evaluation of texts include an assessment of the scientific ideas but emphasise the role of the learner by looking at whether account is taken of student ideas, whether students might become engaged with phenomena and how student thinking can be promoted. The use of the materials is also addressed through a consideration of the extent to which adopting the materials would enhance the science learning environment.

The above-mentioned schemes do not necessarily unpack the way in which the material is presented or the selection of material. There is an ongoing debate in the literature (Bennett, 2003) about the language used in science, whether contextual approaches influence the way science can be taught and what might increase student interest in science. We feel that the framework for linguistic and visual analysis of textbooks developed by Dimopoulos, Koulaidis and Sklaveniti (2003, 2005) could help us understand the way science is being presented in schools. The pedagogic functions of the text and images are described through the concepts of classification and framing developed by Bernstein (1996/2000) and the notion of formality introduced by Halliday (1996):

- **Classification**, which can be strong or weak, tells us something about the relationship between knowledge systems (Bernstein 1996/2000). When it is strong, then each system has its own identity, but when it is weak then there are less specialised discourses. In this study we are interested in assessing the extent to which the science knowledge being presented in science textbooks is specialised or everyday.

- **Framing**, which can be strong or weak, tells us what regulates the communication between reader and text. In cases of strong framing the text is in a higher social position than the reader (Dimopoulos, Koulaidis & Sklaveniti, 2005) and students have less access to the text than in cases of weak framing.

- **Low formality** (Halliday, 1996) would reflect languages that are more like colloquial speech or images that tend to the realistic. High formality arises from use of
specialised scientific text or formal representations (Dimopoulos, Koulaidis & Sklaveniti, 2003).

In using the DKS scheme we are using classification to ask what sort of meanings of science are to be put together and framing to ask how the meanings are to be put together. The particular criteria to be used in analysing the material in the textbooks are presented in Tables 1 for text analysis and Table 2 for analysis of visual representations.

The IMMG scheme developed by Izquierdo et al. (2007) in Spain considers not only the contents and concepts presented in books, but the also the rhetoric (or story) being told. The Spanish researchers suggest that the ‘story’ is told not only through factuality and a consideration of how the facts are built into a book, but also through communicability which can be analysed by looking for indications of the model of science being presented, the model of the reader and the didactical model. An analysis of a text using this approach will tell us what sort of ‘science story’ is being presented in schools. This ‘story’ may or may not offer an approach with which teachers feel comfortable and which learners understand.

Methods and samples
Two chapters of the student book for 7th grade were selected for preliminary analysis. One was an introductory chapter on the nature of science and the other a chapter on properties of matter.

The basic layout is such that there is written text (black and white) occupying about 65% of the width of a page and a side margin of about 35% (Figures 1 and 2). The text is broken up into sections of one or more paragraphs with short bold titles. Sometimes some of the text is given an additional label of being a ‘nugget’ of information. There are also short sections of text which are questions to the student labelled “Do you know the answer?” Visual images are found interspersed in the main text, in the margins or crossing both. The visual images consist of photographs, sketches and cartoons. Some visual images are extensively labelled, some only briefly and some not at all. Suggestions for simple experiments or problems for individuals or groups are marked as assignments and are to be found in gray boxes in the margins. Similarly there are boxes called group work.

For analytical purposes the written text was divided into sections according to section or paragraph breaks, not unlike the methodology used in TIMSS in the mid-1990s (Schmidt, McKnight, Valvere, Houang & Wiley, 1997, Schmidt, Riazen, Britton, Bianchi & Wolfe, 1997). The number of words in a section was most often between 50 and 150. The area of each analytical unit was used as a measure of quantity. The analysis includes the text of the legends for the visual images as well as the “nuggets”. It does not include the short experiments or exercises to be carried out individually, at home or in groups. It is worth noting that the material presented in the books is not divided into distinct lesson plans by the author.

Results and discussion
To avoid repetition and facilitate discussion the main features of the coding scheme are presented with the results in the next section. Examples of coding are taken. The criteria for analysis of text and visual images are found in Tables 1 and 2 respectively as well as the main results.
EXAMPLE 1

Below is a translation of one text section marked no. 55 in Figure 1 called Efnablanda (a mixture) and the results of how it was analyzed.

A mixture

In the atmosphere there are many different gases. Among these are three elements, nitrogen ($N_2$), oxygen ($O_2$) and argon (Ar) and two compounds, carbon dioxide ($CO_2$) and water ($H_2O$). The molecules of these elements and compounds can not combine with each other. The molecules can only mix. Therefore the atmosphere is not called a compound but a mixture. Salt water is a mixture of two compounds, water ($H_2O$) and salt (NaCl).

The text marked no. 55 in Figure 1 was analysed as having strong classification. The text presents reasoned arguments and builds on previously acquired knowledge. Also there are clearly defined criteria of what “can be combined” and examples taken of the atmosphere and salt water.

Framing is weak since the text is primarily declarative, explaining how things are but the author is neither present nor absent to the reader since the text is written in third person singular or plural.

Formality is however moderate since the text is neither highly scientific and formally represented, nor does it use colloquial language. There is some use of specialized terminology (symbols of chemicals) and the number of nouns in a row does not exceed two nouns per time (in Icelandic). The sentences are clear with simple structure and there are equally many verbs in passive voice as in the active voice (in the Icelandic text).
Table 1. Linguistic analysis of two chapters of an Auðvitad book.

<table>
<thead>
<tr>
<th>Classification criteria</th>
<th>Formality criteria</th>
<th>Framing criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranges from scientific knowledge to everyday knowledge</td>
<td>Specialised terminology (use of terms, symbols, equations)</td>
<td>The extent to which the text allows the reader to get a sense of active involvement</td>
</tr>
<tr>
<td>Systematic generalisations or not; explicit by:</td>
<td>Nominalisation (nouns or verbs)</td>
<td>▪ Imperative</td>
</tr>
<tr>
<td>▪ Large number of observations or not</td>
<td>Syntactic complexity</td>
<td>▪ Interrogative</td>
</tr>
<tr>
<td>▪ Use of reasoned arguments</td>
<td>Use of passive/active voice</td>
<td>▪ Declarative</td>
</tr>
<tr>
<td>▪ Use of previously acquired techno-scientific knowledge</td>
<td>Scientific taxonomies (clearly defined criteria, the use of that criteria to fair number of cases and in a common way).</td>
<td>Person (1st, 2nd or 3rd, singular or plural)</td>
</tr>
</tbody>
</table>

Scientific taxonomies (clearly defined criteria, the use of that criteria to fair number of cases and in a common way).

<table>
<thead>
<tr>
<th>Classification</th>
<th>cm²</th>
<th>Formality</th>
<th>cm²</th>
<th>Framing</th>
<th>cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>1055</td>
<td>High</td>
<td>0</td>
<td>Strong</td>
<td>246</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>423</td>
<td>Moderate</td>
<td>288</td>
<td>Moderate</td>
<td>364</td>
</tr>
<tr>
<td>Weak</td>
<td>1525</td>
<td>Low</td>
<td>2715</td>
<td>Weak</td>
<td>2393</td>
</tr>
<tr>
<td></td>
<td>3003</td>
<td>100%</td>
<td>3003</td>
<td>100%</td>
<td>3003</td>
</tr>
</tbody>
</table>

Third of the text in the two chapters analysed is classified strong and two thirds is moderate or weakly classified. This indicates that the text uses everyday language as well as specialised terms of scientific knowledge. Half of the generalisations in the text come from previously acquired knowledge, a third from reasoned arguments and one sixth from observation. In the case of taxonomy more than half of text refers to general applications and 40% of these examples are not accompanied by any defined criteria. This means that in the text there are not many clearly defined criteria and those that are found are used in a common way.

In the case of formality about 90% of the text is evaluated as being informal. In the instances where the formality is moderate or high there are few examples of specialised terminology and the use of the passive voice. Two criteria of the assessment of formality, nominalisations and use of passive voice, are difficult to evaluate because of the nature of the Icelandic favours the use of verbs rather than nouns. This needs to be addressed further with specialists in the Icelandic language. Overall, the syntactic complexity is generally straightforward with few embedded clauses, which makes the text accessible to the reader given the context of it being a science textbook.

The framing of the text analysed is weak. Sentences are mostly declarative and the voice of the author is not obvious. The text demands no active involvement of the reader and the students are often left with the responsibility of what to do with the text they are reading. Here, though, it should be remembered that the suggestions for individual and group projects are not included in this analysis.

In summary, the text relies more on everyday knowledge than scientific knowledge, the text is presented in a relatively informal manner, given that it is from a science textbook, and that the reader often has the responsibility of what to do with the main body of text being read.
EXAMPLE 2

The visual image marked no. 63 on page 15 in Figure 2 was rated as a hybrid since it is a conventional representation with additional realistic features. The function of the visual image was analysed as being metaphorical; it connotes or symbolises meanings and values over and above what they literally represent. For the reader the role of this cartoon is not obvious and does not connect in an obvious way to the content of these two pages – which is volume. Therefore the classification of the image’s function was analysed as being weak. The overall results of classification is therefore weak.

The framing of this visual image is moderate since it is shown from a distance from eye level giving the message that what you see here is a part of your world, something with which the reader is familiar.

The formality of the visual image was analyzed as being low, since the cartoon has no elements of geometrical shapes or alphanumeric strings, presents a variety of colours but few shades of each colour and the background is with details of the whole picture.
Table 2. Analysis of visual images in two chapters of *Auðvitād*

<table>
<thead>
<tr>
<th>Classification criteria</th>
<th>Formality criteria</th>
<th>Framing criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Realistic</td>
<td>• Elements of the technoscientific code</td>
<td></td>
</tr>
<tr>
<td>- Conventional</td>
<td>• Colour differentiation</td>
<td></td>
</tr>
<tr>
<td>- Hybrid</td>
<td>• Colour modulation</td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td>• Contextualisation</td>
<td></td>
</tr>
<tr>
<td>- Narrative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Analytical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Classificational</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Metaphorical</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Classification</th>
<th>cm²</th>
<th>Formality</th>
<th>cm²</th>
<th>Framing</th>
<th>cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>233</td>
<td>High</td>
<td>95</td>
<td>Strong</td>
<td>0</td>
</tr>
<tr>
<td>Moderate</td>
<td>514</td>
<td>Moderate</td>
<td>972</td>
<td>Moderate</td>
<td>648</td>
</tr>
<tr>
<td>Weak</td>
<td>1325</td>
<td>Low</td>
<td>1004</td>
<td>Weak</td>
<td>1423</td>
</tr>
<tr>
<td></td>
<td><strong>2071</strong></td>
<td><strong>100%</strong></td>
<td><strong>2071</strong></td>
<td><strong>100%</strong></td>
<td><strong>2071</strong></td>
</tr>
</tbody>
</table>

The results of analysing visual images of the two chapters show that more than 60% of the visual images are weakly classified. That means those images are realistic and do not build up strong boundaries between the specialised technoscientific knowledge and everyday knowledge. In addition these images are narrative or metaphorical ones.

The degree of formality represents the degree of abstraction in the image. The results show that 95% of the visual images are evenly split between moderate or low formality. That means an emphasis is on colourful images, their background is simple or from real photographic situation and few or no geometrical shapes or alphanumeric strings are present.

Nearly 70% of the images are analysed as having weak framing indicating that the images are viewed from a high and frontal angle and from a close or medium distance.

To sum up the visual images are generally realistic and have low formality and the boundary line between what is everyday and what is scientific knowledge is blurred. Again the reader is left with the task of what to do with the image.

**Discussion and implications**

This preliminary study indicates that the text in the selected chapters rests more on everyday language than specialised terms of scientific knowledge and 90% of the text is evaluated as being informal with few examples of specialised terminology and the use of a passive voice. Overall, the syntactic complexity is generally straightforward with few embedded clauses, which makes the text accessible to the reader given the context of it being a science textbook. The majority of sentences are declarative and the voice of the author is not obvious. The text demands no active involvement of the reader who is left with the responsibility of what to do with it.

What do these results indicate? For children this means that almost half of the text does not call for previously acquired knowledge. Also, the text uses applications of clearly defined criteria in a common way. Sentence construction is straightforward and the
language is rather more declarative with “non-specialist” terms. Often there is no clear author and the knowledge presented is in many respects “fuzzy” – no clear distinction being made between scientific knowledge and everyday knowledge. The overall message is that everybody can learn science!

The images also tell a story. Images in these two chapters are mostly realistic with little degree of abstraction. Most images are in colour, cartoon-drawings or colour photographs, viewed from a high and frontal angle and from a close or medium distance. Most of the images are everyday objects and don’t show “disrepend events”. One fourth of images are cartoons with no clear criteria of what constitutes scientific knowledge and one fifth use Lego-block very familiar to students. Some legends are informative, others not, and most images need a teacher for further explanations. What then is the message to the learner? That science is not really amazing!

Analysing physics textbooks images Berit Bungum (2008) has seen a move from realistic to conventional images, involving a strengthening of the framing, i.e. less involvement of the learner. Also she reports a shift from involvement in experiments to involvement in the sense of recognising science in everyday surroundings. Our results point to a similar conclusion.

These results can be interpreted in the light of the national strategy for scientific and technological development. They can also be viewed through the lens of what we know about how children think and learn. What is most important though is to understand better the kinds of tools which teachers use in science teaching and then what level and type of support teachers and children do need. Gerick and Hagberg (2008) explain that school science makes high demands on the teachers’ comprehension of content knowledge as well as nature of science. Textbooks influence the structure as well as the content of the lessons in the school. With those points in mind our findings will be discussed further with teachers as an opportunity for professional growth and for feedback on the implementation of science and education policy. We will also address the role of the Icelandic language in presenting school science.

Bibliography
http://www.project2061.org/publications/textbook/mgsci/report/about.htm


