‘I just don’t think it’s me’

A study on the willingness of Icelandic learners to engage in science related issues

Kristján Ketill Stefánsson

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University of Oslo

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1. Introduction

In Iceland the wish for a higher enrolment in higher education science has been evident as politicians and leading figures in science and industry describe falling numbers as serious (Samtök iðnaðarins, 2005). The proportion of students enrolled in higher education science courses, including science, medicine, engineering and mathematics, however has been relatively stable at 30-35% of all students during the past 25 years compared with other courses (see Figure 1), the general trend being increased enrolment in all fields of higher education during the period.

In Iceland learners choose early in upper secondary school whether they want to engage further in science and/or mathematics related studies. The enrolment in these courses has traditionally been a matter of much debate by key figures in Icelandic society as this enrolment has been seen as a predictor of future enrolment in higher education. These numbers have risen during the past seven years due to changes in the curriculum limiting the choice of subject fields in the upper secondary school (see Figure 1).

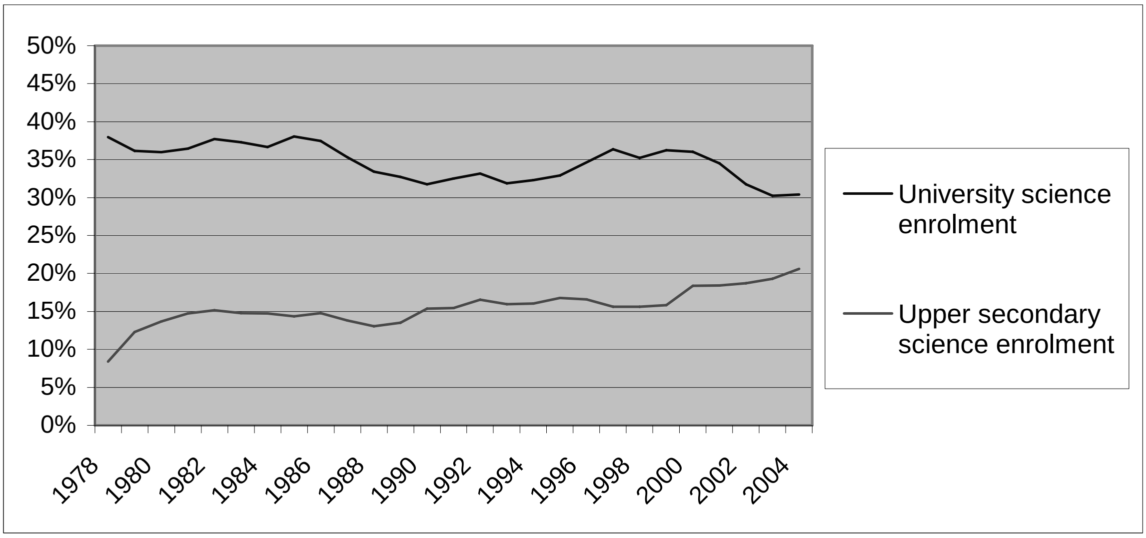

Figure 1 Percentage of science, medicine, engineering and mathematics students in higher education and of science learners in the Icelandic upper secondary school 1978-2004 (Statistics Iceland, 2006).

In a report on increasing human resources for science and technology in Europe, alarming signals in EU member countries are described in this way:

> *For several years now there have been warnings from universities that the number of students has been declining sharply in some disciplinary areas, namely physics, chemistry and mathematics.*
>
> *In some countries, there seems to be increasingly pronounced evidence of a decline in the interest of young people to study Science and retain the option of pursuing Science -related careers.... In the past decade, there seems to have been a growing perception that the problem has become more acute in some countries. This has been linked to the liberalization of the system of subject choice in schools in many countries and the increasing variety of courses being offered at university* (EU, 2004).

Alarm bells can be heard from industry, politicians and media because everyone seems to agree that scientific literacy is one of the keys to the welfare and prosperity of every nation. Science education seems to play a big part in maintaining and improving both welfare and prosperity of every nation.

The main purpose of this thesis is to give stakeholders in science education access to information that might help improve school science for future learners, especially by focusing on results that might be helpful to increase the willingness to engage in science related issues as reflective citizen. This terminology will be explained further in Chapter 2.4.

The research has both an explanatory and an exploratory part. The explanatory part includes a review of some previous research in the area of willingness to engage in science and the adaptation of a framework that is used in the context of Icelandic learners. The exploratory part includes the gathering of new information in the area of learner willingness to engage in science related issues in an Icelandic context.

In short the research question can be summed up in this manner: How do learner perceptions of science related issues relate to their willingness to engage in those issues and what do we know about these perceptions in the context of Icelandic learners?

2. Research on attitude related topics

The marked interest in research on attitudes towards science in the 1960s and 1970s is commonly associated with the wish for a higher enrolment in higher education science and technology courses during the period. The reason for the declining research on attitudes towards science during the past two decades is primarily associated with the rapid pace of curriculum reforms in the period and the change of focus in research effort towards the implementation of these reforms (Bennett, 2003).

The major trends in research in science education since the 1950s have been referred to as the three C's – curriculum, constructivism and comparison. (Macdonald, 2000). In the 1950s and the 1960s the main focus was on writing curriculum materials and encouraging increased enrolment into the higher education science and technology courses. Models were suggested for studying science as scientists, including an emphasis on process skills and on discovery learning. The work of Bruner, Gagné and Piaget had an influence on the design of the curriculum materials. In the 1970s research on the learning process became more evident and in the 1980s research in learners' preconceptions emerged as a research field. In the 1990s constructivist theories based on the ideas of Piaget and especially Vygotsky started to dominate the research area. From the mid-1980s onwards standards became an issue and many countries prepared national curricula which varied in approach and complexity. During recent years we have experienced the third 'C' in the extensive comparative studies like Third International Mathematics and Science Study[1] (TIMSS) and Programme for International Student Assessment (PISA).

In this chapter the results of attitude studies are presented and what they seem to suggest about relationships between attitudes, interest, learning and achievement and why understanding attitudes is an important issue both for science educators and for the public understanding of science. Much of research and development in science education in one way or another has addressed the two issues of achievement and attitude – what should learners know and be able to do and how their interest in science could be enhanced. The research in which I have been engaged has its focus on the learners' attitudes. From the reviewed literature three sorts of studies of attitudes towards science education can be identified: career related studies, achievement related studies and studies that emphasize different parts of perceptions of science without connecting them directly to achievement or career choice. This literature review chapter will address the following questions: What has been done in attitude related research in science education? Why has it been done? How are key terms defined?

2.1 Career related studies

The influences and motivations on which students base their choice of career in the United Kingdom were studied by Kniveton (2004). In all 348 young people aged 14-18 years old completed a questionnaire and took part in an interview concerning their

[1] Now Trends in International Mathematics and Science Study.

choice of career. The greatest influence on their choice of career was their parents followed by their teachers. There was evidence of gender differences, with same sex parental influence. Although seeking further education was the most popular next step for most respondents, marriage was more important to females than to males. Overall motivation towards work was found primarily to involve money and liking the job. Very low on the list were long term goals, such as personal development, career advancement or pensions. Most noticeably, the students considered the status derived from possessions rather than employment.

Similarly Mau (2003) investigated factors that influence persistence in science and engineering (SE) related career aspirations in the United States. The research was conducted in 8th grade with three follow-ups, the first in 10th grade, the second in 12th grade and the third when most of the participants had been out of high school for two years. The base sample was 24.599 learners and nationally representative. Of these only 827 (3.4%) aspired to SE related careers. Of these 827 only 176 (22%) continued with the same aspirations in SE six years later. This was measured by the question 'Which occupation do you expect or plan to have when you are 30 years old?' Mau (2003) gathered data about a number of variables in a search to find factors influencing science and engineering related career aspirations. These factors were: standardized tests, locus of control, self-concept, socio-economic status, parental involvement, parental expectation, number of siblings, math self-efficacy and reading self-efficacy.

Persistent learners scored higher than did non-persistent learners on all of the variables studied and young women were less likely than men to persist in aspiring in SE careers. Academic proficiency and math self-efficacy were the strongest predictors of persistence in SE careers. It seemed that parental expectations, school involvement and the academic program were effective in identifying learners who aspired to nontraditional careers but were less effective in explaining persistence in SE aspirations. Although academic proficiency was a significant predictor for persistence in SE aspirations, it was less predictive than math self-efficacy (Mau, 2003).

Changes in the educational and career goals of 66 females in the United States who completed surveys in Grades 7 and 12 were examined by VanLeuvan (2004). Over time the career aspirations in science, technology, engineering and mathematics (STEM) decreased. The learning and discovery and using mathematics were among the influencing factors reported by young women enjoying STEM careers. The girls that reported a lack of interest mentioned influencing factors like disliking doing the mathematics and the hard work required.

Relationships between factors in science education and student career aspirations were studied by Wang and Staver (2001) in an attempt to disentangle relationships among factors that influence career aspirations within a science education context. The researchers used data from the Longitudinal Study of American Youth (LSAY). The LSAY data contain more than 8000 variables from a six year panel study of mathematics and science education in U.S. public, middle and high schools. Approximately 3000 U.S students were randomly selected at the 10th grade level to take an academic test and complete a questionnaire in the 1987-1988 academic year.

Wang and Staver (2001) refer to researchers in the field of psychology (Plucker, 1998; Quaglia and Perry, 1995) when describing the construct of career aspiration. As a construct in psychology, the learners' aspiration can be specified by two components: ambition and inspiration. Ambition refers to students´ sense of educational and vocational goals for the future. Inspiration refers to students' involvement in activity for its intrinsic value and enjoyment (Plucker, 1998). In the research conducted by Wang and Staver (2001) inspiration had a higher factor loading on career aspiration than ambition. The researchers conclude that the difference in factor loadings suggest that career aspiration is more influenced by the value of science training than ambition.

Among factors of educational productivity, educational outcome had the strongest link with career aspiration. The outcome factor was indicated by science achievement and student attitude toward science. An inspection of the factor loadings showed more weight on student attitude toward science. Instructional quantity indicated by student homework and work ethics was another factor linked with career aspirations. The researchers stress the importance of student intrinsic effort. A positive effect from the home environment was interpreted from the factor loadings. The factor of peer environment in the study revealed a multivariate relationship in the context of science and the researchers called for more empirical studies on these relationships in the context of school science (Wang & Staver, 2001).

Science career related possible selves of adolescent girls were researched by Packard and Nguen (2003). The researchers refer to the work of Markus and Nurius from 1986 when defining possible selves as images of what people hope to become, expect to become and fear becoming in the future. Using a possible selves theoretical framework the researchers examined whether and how adolescent girls' images of themselves as future scientists changed during their transition from high school to college. The researchers interviewed 41 female high school graduates that had enrolled in an intensive mathematics and science program while in high school. The interviews where focused on their perceptions of factors that influenced their career plans over time.

Within the sample only six participants maintained their initial career aspirations from early to late adolescence, even though 30 persisted within science, mathematics, engineering and technology related fields. Results of the study suggest that mentoring relationships, developed through intensive summer programs or work related internships, are critical to ongoing career development. Packard and Nguen (2003) found that girls appear to be concerned with helping others through their careers. Therefore the researchers claim that discussions of how careers impact on communities need to be an explicit focus of career programs so careers are not eliminated due to lack of information or stereotypical perceptions.

2.2 Achievement related studies

The relationship between self-beliefs and science achievement has been studied by House (2003). The researcher states that current perspectives on instructional design and media selection have emphasized the importance of considering self-beliefs and motivation when designing effective lessons. In his study he used data from the TIMSS Population 2 International Sample (13-year-olds) from Hong Kong. Results regarding science achievement showed that learners who had high test scores tended to indicate that they enjoyed learning science and that science is important to everyone's life; they also were less likely to feel that science is boring. The findings of the study indicated that students who felt that internal and controllable factors (such as natural talent and hard work studying at home) were needed for science and mathematics achievement at school also tended to have higher achievement test scores.

The influence of family demographics on mathematics achievement in 34 countries with different economic development levels were explored by Schiller *et al.* (2002). Using data from TIMSS, the researchers found that the positive effect of higher parents' education on middle school mathematics test scores was consistent among the 34 nations examined. The educational stratification due to socioeconomic status did not seem to differ between the nations examined. The academic disadvantage of living with only one natural parent seemed to be greater in the more developed nations.

The effects of motivation, interest and academic engagement on mathematics and science achievement were examined by Singh *et al.* (2002). The researchers stated that although the cognitive abilities of the students and their home backgrounds are important predictors of achievement, in recent years affective variables have emerged as salient factors affecting success and persistence in mathematics and science subject areas. The authors used the nationally representative sample of 8th graders drawn from the National Education Longitudinal Study 1988 in the United States. They used structural equation models to estimate and test the hypothesized relationships of two motivation factors, one attitude factor, and one academic engagement factor in achievement in mathematics and science. Results supported the positive effects of the two motivation factors, attitude and academic time, on mathematics and science achievement. The strongest effects were those of academic time spent on homework.

2.3 Perception of science related studies

The effect of gender stereotypes in science education among 1140 11-16 year olds in the United Kingdom have been studied by Breakwell *et al.* (2003) using quantitative methods and a questionnaire. The study shows that liking science is related to gender self-image and to gender stereotypes among adolescents. The interesting part of their findings is that this relation is not as simple as science being defeminizing and masculine. The results show the importance of processes of subjective group dynamics by which learners define and protect the meanings and boundaries of important group memberships. Girls who liked science less appeared to exclude the perceived in-group deviant (the girl who likes science) from their gender in-group. Despite the so-called masculine image of science these effects were not significantly stronger among girls than boys. Question where raised whether efforts to 'feminize' science might play into the hands of 'macho lads' that would define their gender group so as to exclude the 'boy who likes science' from a secure membership. It is therefore argued that gender differences in science education should be attributed partly to subjective group dynamics and not solely to images of science.

Adolescent's science peer relationships and perceptions of the possible self as scientists were studied by Stake and Nickens (2005). The research sample was 163 male and 161 female gifted high school students who participated in summer science enrichment programs in the United States. Information was gathered before the programs and again six months later. One of the main results was that girls tended to have less peer support for their science interest than boys. Both program related and non-program related science peer relationships were associated with changes in possible self as a scientist at post testing and at six month follow-up. Girls reported a stronger social niche with fellow program participants and stronger science peer relationships than did boys. The findings support the prediction of the researchers that having peers with whom to share science interests enhances both girls and boys imagined future personal life as scientists.

The teacher's perception of scientists has been researched by McDuffie (2001). In his research 550 preservice and inservice teachers (80% women) from Eastern Pennsylvania and New Jersey in the United States shared relevant data about perceptions of scientists. Analysis of written descriptors revealed that 50% of the sample considered scientists as 'smart' or 'intellectual', 25% described scientists as practical, concrete thinkers who solve problems experimentally and work precisely and 13% used the terms 'geeks' and 'nerds' in their descriptions of scientists. Analysis of drawings revealed that 71% of the scientists were middle-aged and 84% were male, 50% of the sketches included scientists wearing glasses and 36% with unconventional hair styles and 50% were drawn wearing laboratory coats. The scientists were almost always alone and in 54% of the sketches surrounded by objects of research.

McDuffie (2001) concludes that teachers' sketches fail to depict science as a collaborative endeavor and the work environment of scientists was not depicted as a broad world of investigation. The stereotypes of scientists held by preservice and inservice teachers are more or less the same. Comparison of drawings of students reveals that the teacher's stereotypes are the same as their students on most significant characteristics. The researcher therefore asks a simple but potent question:

> *Are teachers unwittingly communicating a biased viewpoint and prompting children to create a distorted image of scientists?* (McDuffie, 2001)

2.4 Concepts underlying research on attitudes

Research in attitudes towards science have different aims and is in it itself complicated in its search for operational definitions of attitudes and relationships between factors affecting attitudes. Therefore a review of the concepts underlying research on attitudes is necessary to clarify the field under consideration.

In recent years we have witnessed increasing policy recommendations relating to the need for a scientifically literate public (Millar & Osborne, 1998; Osborne, 2002; Sjøberg, 2004). Preparation of talented learners for future careers in science, mathematics and technology has not been lost in these reform movements, but rather has been subsumed within the broad vision of enhancing science literacy for all students (Wang & Staver, 2001). The consequences can be seen in an increased focus on research on attitudes towards science. The increased focus on attitudes can be seen for example in the OECD's redefinition of the term *scientific literacy*.

The PISA assessments conducted by the Organization for Economic Cooperation and Development (OECD) were developed from 1997 in three domains, reading, mathematics and science. The first PISA assessment was carried out in 2000 and an assessment is carried out every three years. Each assessment specializes in one particular domain, but also tests the other domains studied. In 2000, 265 000 students from 32 countries took part in PISA; 28 of them were OECD member countries. In 2002 the same tests were taken by 11 more 'partner' countries (i.e. non-OECD members). The main focus of the 2000 tests was literacy, with two-thirds of the questions from that domain. Over 275 000 students took part in PISA 2003, which was conducted in 41 countries, including all 30 OECD countries. The focus was mathematics, testing real-life situations in which mathematics is useful. Problem-solving was also tested for the first time (OECD, 2006). In 2000 and 2003 PISA had science as a minor domain and was defined scientific literacy as follows:

> *Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity* (OECD, 2005b).

In 2006 52 countries are expected to participate; the main focus of PISA 2006 is science, and in 2009 reading will again be the major domain. In the lifespan of the PISA research the discussions about science education have been wide-ranging and the purposes of science education have also been redefined and broadened. As a result of this the OECD has redefined the term scientific literacy as an individual's:

> *…scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues; understanding of the characteristic features of science as a form of human knowledge and enquiry; awareness of how science and technology shape our material, intellectual, and cultural environments; and willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen* (OECD, 2005b).

The last section of the definition is of special relevance to this research as it affirms the importance of the *willingness to engage in science related issues, and with the ideas of science, as a reflective citizen*. The willingness to engage in science related issues is important not only with regard to the choice of educational pathways and careers but more importantly to the role of being a reflective citizen. I will use this broad definition of the term *engagement* in science during this essay.

In a draft version of the conceptual framework of PISA 2006 (OECD, 2005a) the PISA researchers refer to Boekaert's work from 1993 when stating that engagement is an essential part of scientific literacy. Boekaret states that engagement is crucial for the acquisition of proficiency, but it is also an important outcome of education. The relationship between engagement and achievement is almost certainly a reciprocal one: The more engaged students are in the process of learning, the more they will tend to learn, but levels of proficiency may also influence the level of engagement.

The learners' engagement in science is addressed directly in PISA 2006 through a conceptual framework that gives a comprehensive picture of the complexity of the research area. The framework is divided into two dimensions – processes and context. The processes of the learners' engagement drawn from the research literature are:

- self related cognitions,
- value beliefs,
- emotional factors,
- motivational orientations, and
- behavior related variables

Each of these processes is seen in the different light of their context such as:

- general context,
- health,
- resources,
- environment,
- hazards, and
- frontiers

After defining the conceptual framework and indicating its scope the PISA developers state that the limits of testing time and students' test motivation make it difficult to get measures of all relevant processes of engagement for all relevant contexts of science in PISA 2006 (OECD, 2005a). Some of the research reviewed earlier touches upon one or more of the processes listed by the PISA researchers. This indicates the size and the complexity of the research area on the willingness to engage in science related issues. The PISA researchers include the dimension of the science context which can not be underestimated in the light of its effect on different career aspirations.

Three characteristics of the research literature on attitudes to science have been identified by Bennett (2003). First, the amount of research conducted in the field is substantial. Second, the interest and activity in the field seems to have been greatest in the 1970s and the early 1980s, with much less being written in the last decade or so, and third, a substantial proportion of the literature focuses on the problems and difficulties associated with research into attitudes to science.

The fact that so much of the literature focuses on the problems and difficulties associated with the research into attitudes to science reflects the lack of clarity in an area where psychological, sociological and pedagogical theories meet:

> *Even a cursory examination of the domain reveals that one of the most prominent aspects of the literature is that 30 years of research into this topic has been bedevilled by a lack of clarity about the concept under investigation* (Osborne, 2003).

One of the major problems is the need for precision in defining key terms. Attitudes are one of these terms and a central term, and thus problem, in my research.

Different terminology has been used in studies covering much of the same ground. Information about attitudes can be found in studies of pupils 'interest' in science, their 'views' of science, the 'images' they hold of science and their 'motivation' to study science. Bennett (2003) herself uses the term 'dispositions towards' as an umbrella term when identifying different attitudinal constructs for attitudes to science. Difference in terminology can also be found in the literature for the term 'attitudinal construct'. Bennett (2003) uses the term 'attitudinal strands' and Bricheno, Johnston, and Sears (2000) use the term 'groups of attitudes'.

It has been suggested for many years that attitudes have affective, cognitive and conative (behavioral) strands. Current understandings suggest that affective attitudes are the root of both cognitive and behavioral attitudes, so that how we behave is a result of how we think and an inter-relation of how we feel and think. Education has generally focused on changing scientific attitudes which are rooted in behavior and cognition. Research on the other hand has concentrated on identifying aspects of affective strands of attitudes and the effects of affective attitudes on behavior and cognition (Bricheno, Johnston, & Sears, 2000). This division of attitudes into three parts is made simpler and directly related to science education by Bennett (2003) who draws on the work of Oppenheim (1992) and defines attitudes as:

- a function of what you know,
- how you feel about what you know, and
- how this influences your likely behavior.

Bricheno *et al.* (2000) refer to research on science related attitudes carried out by Fraser (1981). In the study, seven groups of attitudes where identified and measured. They are attitudes:

- towards the social implications of science,
- towards the normality of scientists,
- to scientific inquiry,
- which are needed to be scientific,
- towards the enjoyment of science lessons,
- towards a science as a leisure interest, and
- towards a career in science.

Bennett (2003) identifies five attitudinal strands from her review of the literature. These are:

- dispositions towards school science,
- dispositions towards science outside school,
- dispositions towards the relevance and importance of science to everyday life,
- dispositions towards scientists, and
- dispositions towards scientific careers

The attitudinal constructs to science reviewed by Bennett (2003) and Bricheno *et al.* (2000) cover much of the same grounds. They include general dispositions or attitudes towards school science, scientists, scientific careers and science outside school. The five attitudinal constructs identified by Bennett (2003) seem more general while most of the constructs identified by Bricheno *et al.* (2000) are identical or can be fitted within the constructs identified by Bennett (2003).

From his review of the literature Osborne (2003) points out that attitudes towards science do not consist of a single unitary construct. They rather consist of a large number of *subconstructs* all of which contribute in varying proportions. He points out a number of such constructs:

- the perception of the science teacher,
- anxiety toward science,
- the value of science,
- self-esteem with regard to science,
- motivation towards science,
- enjoyment of science,
- attitudes of peers and friends towards science,
- attitude of parents towards science,
- the nature of the classroom environment,
- achievement in science, and
- fear of failure on a course.

The constructs reviewed by Osborne are much broader then those reviewed by Bennett (2003) and Bricheno *et al.* (2000) and include social and psychological related constructs. The constructs reviewed by Osborne have an interesting resemblance to many of the processes of student engagement drawn from the research literature by the PISA researchers. This can for example be seen by the emphasis on self related cognitions such as self-esteem with regard to science and emotional factors such as anxiety toward science and fear of failure on a course. After comparing these different constructs it is not unreasonable to assume that the constructs identified by Bennett (2003) on one hand and Bricheno *et al.* (2000) give most meaning to the subconstruct 'value of science' in Osborne's review or 'value beliefs' in the engagement framework of the PISA researchers. This puts the constructs identified by Bennett (2003) and Bricheno *et al.* (2000) in an interesting relation with an undefined number of social and psychological related constructs

3. Conceptual development of the research question

In 2003 quantitative data was collected in Iceland, describing amongst other things the perceptions secondary school learners had of school science, science and scientists and science related careers. The data was collected as part of the international Relevance of Science Education (ROSE) research (Sjøberg, 2002). Three students, of which I was one, collected the data and presented the results in our final undergraduate project (Gunnarsson, Haraldsson, & Stefánsson, 2003).

The Icelandic project used descriptive statistics to describe the expressed interest in learning about different science related issues. Part of the ROSE data was not analyzed as the work grew beyond the scope of our project. The unanalyzed ROSE data from Iceland, which we collected, makes up the bulk of the quantitative data I started of with in this research.

This quantitative data was not developed by me and the suitable application of this data to a research question which interested me became a long process. The nature of the quantitative data called for a framework that could situate the learner perceptions of science related issues in relation to their willingness to engage in science related issues. As this kind of framework was not readily available in the research literature the search for a framework for the interpretation of the ROSE data from Iceland became a research question in itself.

3.1 ROSE

This section is based on information from the ROSE handbook that includes the background, rationale, questionnaire development and data collection for ROSE (Schreiner & Sjøberg, 2004)

The ROSE study is based on the conviction that the science and technology curriculum should be adapted to the needs of learners. An important aspect of the ROSE research is its contribution to the 'positive' attitude discourse which is often taken to mean 'accepting' attitudes. The ROSE study challenges the notion that the aim of science and technology education is to develop 'positive' attitudes in this narrow meaning. The developers of ROSE rather think that students should develop an attitude of critical reflection towards science and technology issues. This may mean that learners embrace and support some sorts of science and some sorts of technology, and oppose and discourage others.

The keyword of ROSE and the first word of its acronym is 'relevance'. The word relevance in the ROSE research is used as an umbrella term for a wide spectrum of factors that broadly speaking belongs to the affective domain. The developers of ROSE state that they could have used other words, such as meaningful, motivating, interesting, engaging or important. Therefore they caution users of the data that relevance should not be interpreted in a narrow sense.

The ROSE instrument tries to assess science and technology related experiences that learners have, the kind of interest they have in science and technology related content, and the views and attitudes they have towards science and technology in society. The study also elicits what learners feel about the science and technology they have experienced in their schooling, and descriptions of the plans and ambitions they hold for their future life. Special emphasis is put on social and psychological related constructs learners' attitudes to and perceptions of environmental challenges

Previously I referred to attitudes as a function of what you know, how you feel about what you know and how this influences your likely behavior (Bennett, 2003). By this definition the ROSE data can provide indicators of what the secondary school learners feel about school science, science, scientists and environmental issues and more. What I need on the other hand is a deeper understanding of the two other components of the definition; what the learners know about the issues under consideration and how this influences their likely behavior.

3.2 Intentions and reality

In my search for data that could give me a deeper understanding of the context and meaning of the Icelandic learner perceptions I was invited to join the *Intentions and reality* project in Iceland. The project seeks to describe and analyze the provision of science education in Iceland in the late 1990s and early 2000s following changes in the law, a revised national curriculum, the reintroduction of a standardized examination in science and the participation of Iceland in international comparative studies (Macdonald, 2005). This contact led to my participation in the project. I went to Iceland for two months in early 2006 and worked on the project. During this period I gathered the interview data used in this essay in an attempt to get a clearer picture of the dispositions of Icelandic 15 years olds towards science. During the formulation of the interview questions (described in Chapter 4.2.1) the lack of a theoretical framework became more and more evident. From a range of sources, some of which have been reviewed in the previous section, I chose to adapt the model of achievement choices created by Eccles (2005) and colleagues. The model is described in the following section.

3.3 Model of Achievement Choices

I wanted a model to address the wide spectrum of attitudinal constructs thrown up by the literature search. A collegue suggested that I look into the field of social psycology and mentioned work by Eccles, a researcher in the United States. Eccles (2005) with others has developed the Model of Achievement Choices to address the complexity of achievement related choices. The model is drawn from and built on studies of motivational and social factors influencing long- and short-range achievement goals and behaviors as career aspirations, vocational and avocational choices, course selections, persistence on difficult tasks, and the allocation of effort across various achievement related activities. All the references relating to the Model of Achievement Choices in this section are from a section of the Handbook of Competence and Motivation (Eccles, 2005).

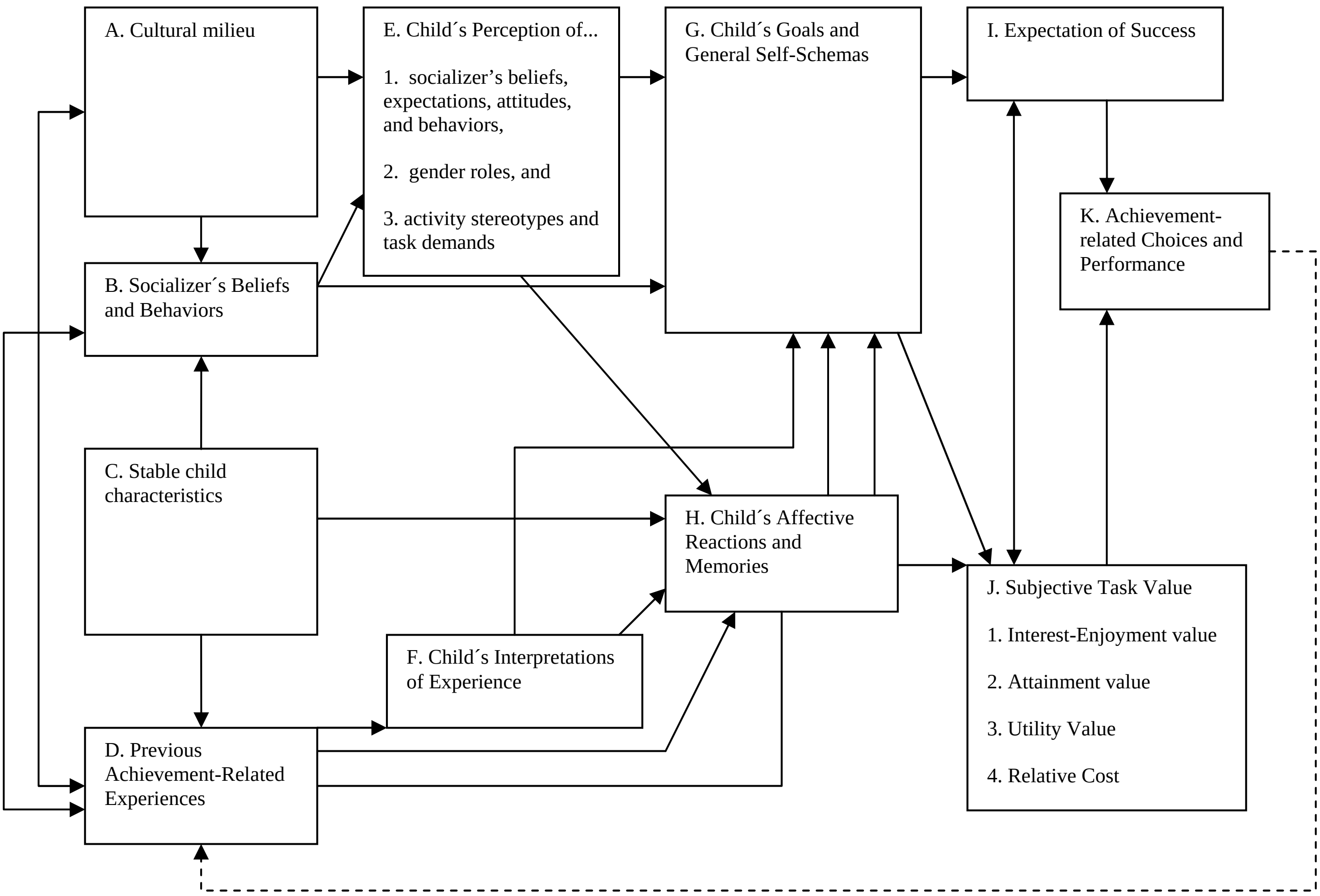

Figure 2 General expectancy value model of achievement choices (Eccles, 2005).

Seeing the striking gender difference in the educational and vocational patterns of males and females, Eccles and her colleagues began this work with a particular interest in the motivational factors that might underlie the gender differences in achievement related choices. They proposed that educational, vocational and other achievement related choices are most directly related to two sets of beliefs: the individual's expectations of success (Box I), and the importance or value the individual attaches to the various options perceived by the individual as available (Box J).

3.3.1 Expectation of success

In the model of achievement choices Expectation of success is defined as an individual construct in the model labeled with the letter I. As can be seen in Figure 2 the construct I 'Expectation of success' emerges from construct G 'Child's Goals and General Self-Schemas' and interacts with J 'Subjective Task Value' in forming K 'Achievement related Choices and Performance'.

Expectation of success depends on the confidence the individual has in his or her intellectual abilities and on the individual's estimation of the difficulties of the course. These beliefs are shaped over time by the individual's experiences with the subject matter and by his or her subjective interpretations of those experiences.

3.3.2 Subjective Task Value

The importance or value the individual attaches to the various options perceived as available is called 'subjective task value' or STV as it will be referred to here after. The Eccles model also specifies the relation between the beliefs regarding success and STV and the cultural norms, experiences, aptitudes and those personal beliefs and attitudes that are commonly assumed to be associated with achievement related activities.

The creators of the general-expectancy value model of achievement choices assume that *STV is a quality of the task that contributes to the increasing or decreasing probability that an individual will select it.* They define this quality in tasks in terms of four components:

1. *Attainment* value or the value an activity has because engaging in it is consistent with one's self-image,

2. *Intrinsic or interest* value, expected enjoyment of engaging in the task,

3. The *utility* value of the task for facilitating one's long-range goals or helping the individual obtain immediate or long range external rewards, and

4. The *cost* of engaging in the activity.

I will now discuss each of these briefly.

Attainment value

Attainment value in this research could be defined in terms of the personal importance of doing well on or participating in science. The creators of the model draw parallels to the work of Connell and Wellborn (1991, in Eccles, 2005) who argued that people's motivation for engaging in a task is influenced by the extent to which the task provides the opportunities to fulfill their basic needs for:

1. autonomy,

2. social relatedness, and

3. sense of competence.

In addition Eccles adds the following basic needs and values:

4. the need to feel that what one does matters in a fundamental important way to one's social group, and

5. the need to feel respected and valued by one's social group.

The creators of the Eccles model believe that success and failure experiences, as studied in mastery attempts by Albert Bandura (1986), influence the attainment values attached to whole categories of activities. They believe that the attainment value of various tasks is influenced by the affordance[2] provided by these tasks to fulfill a whole array of individual needs and personal values. The researchers describe the

[2] Affordance: A property of an object, or a feature of the immediate environment, that indicates how to interface with that object or feature. For example, in using a door one uses its property of being able to open up or close off a space.

component parts of the images that we develop as we grow up, images that tell us who we are and what we would like to be:

1. Our conception of our own personality and capabilities,
2. Our long range goals and plans,
3. Our schema regarding proper roles of people ‘like us’ (e.g. boys vs. girls) as well as our more general social scripts regarding proper behavior in a variety of situations,
4. Our instrumental[3] and terminal values,
5. Our motivational sets or goal orientations, and
6. Our images of our ideal or hoped-for selves.

Essentially Eccles (2005) argues that individuals perceive tasks in terms of certain characteristics that can be related to their needs and values. In turn, tasks that fit well with one’s values, goals, or needs will be seen as having high STV; tasks that do not fit well, or that actually are in opposition to one’s values, goals or needs, will be seen as having low or negative STV. As an example, if helping other people is a central part of an individual’s personal identity, then that person should place a higher value on ‘helping’ rather than on ‘not helping’ occupations.

Eccles and her colleagues also refer to the work of several scholars interested in goal orientations that have consequences for her definition of attainment values. The goal orientation theorists hypothesized that achievement tasks vary along two dimensions.

1. The extent to which mastery or improvement is stressed, and
2. The extent to which doing better than others is stressed.

Goal orientation theorists also hypothesized that individuals differ in the salience of these two dimensions. This is assumed to be a central part of one’s core self. In summary the creators of the model assume the following in their discussion about the attainment value:

1. Individuals seek to confirm their possession of those characteristics central to their self-image,
2. Various tasks provide differential opportunities for such confirmation,
3. Individuals place more value on those tasks that either provide the opportunity to fulfill their self-image or are consistent with their self-image and their long-range goals, and
4. Individuals are more likely to select tasks with high subjective value than tasks with lower subjective values.

The subjective value is assumed to work to the extent that groups of people, such as males and females, come to have different self-images, needs, goals, and personal

[3] Instrumental values: Values such as ambition, courage, persistence, politeness. They are not the end but a means of achieving terminal values

values through the processes associated with sociocultural learning, and various activities will come to have different subjective value for males and females.

Intrinsic and Interest Value

'Intrinsic value' is reserved for the enjoyment one gains from doing the task or the anticipated enjoyment one expects to experience while doing the task. Eccles (2005) refers to the idea of flow as proposed by Csikszentmihalyi (1988, in Eccles, 2005), who discussed intrinsically motivated behavior in terms of the immediate subjective experience when people are engaged in an activity. This experience, labeled 'flow', is characterized by:

1. Holistic feeling of being immersed in, and of being carried by, an activity,
2. Merging of action and awareness,
3. Focus of attention on a limited stimulus field,
4. Lack of self-consciousness, and
5. Feeling in control of one's actions and the environment.

Flow is defined as only being possible when people feel that the opportunities for action in a given situation match their ability to master challenges, but both the challenges and skills must be relatively high before a flow experience becomes possible. An example of flow in science in the case of this research could be the feeling of a learner being immersed in a physics problem to be solved.

Eccles (2005) refers to the ideas of interest value examined by several scholars and how it relates to the notion of intrinsic value. These ideas differentiate between individual and situational interest as well as value and feeling related interest. The desire to learn is categorized under individual interest and subdivided into three parts: preference for hard or challenging tasks, learning that is driven by curiosity or interest and striving for competence and mastery. The second part of the division *learning that is driven by curiosity or interest* fits the definition of interest value, according to Eccles. This definition will be kept in mind when considering intrinsic/interest value in this research.

Utility value

'Utility value' or usefulness, refers to how a task fits into an individual's future plans. In this research it might be engaging in science in order to become a pilot. The activity is a means to an end rather than an end in itself. Eccles makes it clear that in some cases utility value can be quite closely related to the attainment value. For this particular research the utility value might be an interesting factor when learners argue for their preferred choice of studying science. Some learners might be fixed on a certain type of outcome for their schooling and will therefore view science as a means to an end rather than an end in itself.

Perceived cost

Eccles (2005) and her colleagues emphasize that the 'cost' of participating in an activity is especially important to choice of activity. Cost is said to be influenced by many factors, such as anticipated anxiety, fear of failure, fear of the social consequences of success, such as rejection by peers, or anticipated sexual harassment or discrimination, or anger from one's parents or other key people, and fear of loss of a sense of self-worth. Eccles (2005) refers to the work of Covington (1992, in Eccles 2005) and his self-worth theory when she describes the motive for self-worth as the desire to establish and maintain a positive self-image, or a sense of self-worth. Because children spend so much time in classrooms and are evaluated so frequently there, Covington argued that protecting one's sense of academic competence is likely to be critical for maintaining a positive sense of self-worth. School evaluation, competition, and social comparison can make it difficult for some children to believe that they are competent academically. This is very interesting when seen in the Icelandic context of emphasis on centralized evaluation results for schools being made available in the media. Furthermore the competitive nature that often thrives in school science could be a factor in restricting the same beliefs. Eccles describes the work of Covington in outlining strategies children develop to avoid the appearance of a lack of ability, including procrastination, making excuses, avoiding challenging tasks, and not trying.

According to the model, cost can also be conceptualized in terms of the loss of time and energy for other activities. Thus, cost refers to what the individual has to give up in order to carry out a task. In the case of this research this could be, 'Do I do my homework in science or do I make a short film with my friends?' This can also relate to the anticipated effort one will need to put into task completion. In the case of this research this could be, 'Is working this hard to get the highest grade in science worth it?'

3.4 Adapted model of achievement choices

As previously mentioned this research started from a consideration of results from the ROSE research about learners' attitudes to science and my wish to understand how these attitudes affected learner willingness to engage in science related issues. The data from the ROSE research had no standardized framework for the different settings in which the research was conducted so I felt that a framework for the Icelandic learners' context was needed.

I also realized in my work as an assistant ROSE researcher at the Institute for Teacher Education and School Development in the University of Oslo that attitudes towards science seemed to have a strong relation to context in that there were strong negative correlations between the level of interest measured by ROSE and the Human Development Index. I will address this in more detail in Chapter 5.1. These correlations have been studied further by Schreiner (2006).

The general expectancy-value model of achievement choices developed by Eccles (2005) and her colleagues provided a base for a conceptual framework for interpreting some of the personal beliefs and attitudes found in the ROSE data.

Some of the perceptions measured in the ROSE questionnaire could be related to construct 'E. Child's perception of…' of the Eccles model (see Figure 2) where there are three sub-categories:

1. Child's perception of socializers' beliefs, expectations, attitudes, and behaviors,
2. Child's perception of gender roles, and
3. Child's perception of activity stereotypes and task demands.

Learner perceptions are presumed to be molded by their social and cultural milieu and the beliefs and behaviors of their socializers, according to Eccles (2005), which in the case of my research are all the individuals affecting the learner including parents, peers and teachers. This opened an opportunity for the Icelandic ROSE data to be interpreted within the relevant context. I decided to take group interviews to deepen the understanding of the Icelandic context of the attitudinal constructs under consideration by working with the Icelandic ROSE data and working with Icelandic learners.

In the adapted model perceptions (E, Figure 3) affect the learners' goals and general self-schemas (G, Figure 3). If the model is considered carefully it can be seen that many other things also affect the learners' goals and general self-schemas, both directly and indirectly.

- Socializers' beliefs and behaviors (B, Figure 3) affect the learners' goals and general self-schemas directly and indirectly through perceptions and affective reactions and memories (H, Figure 3).
- The same thing can be said about the child's interpretations of experience (F, Figure 3); it affects the learner's goals and general self-schemas directly and indirectly through the child's affective reactions and memories.
- The most important part affecting the learners' goals and general self-schemas is the learners' affective reactions and memories, indicated with two parallell arrows in the model (H, Figure 3).

It is important to realize that all these parts of the model (B, C, D, F and H, Figure 3) affect learners' goals and general self-schemas directly and indirectly.

The child's goals and general self-schemas affect both expectations of success (I, Figure 3) and the STV (J, Figure 3). Finally, the expectation of success and STV interact and affect the achievement- related choices and performance.

With all the above in mind, I have adapted Eccles' model to reflect both key points in the model and data from Iceland that was available or could be collected (shaded boxes, Figure 3).

I have access to social indicators from a range of countries and by taking social environment as one measures of cultural milieu I have information on part A of the adapted model (Figure 3).

In adapting the general expectancy-value model I talk about 'perceptions' and instead of using the term 'child's perception' I chose to use the term 'learner perceptions' (E, Figure 3). This is done as my research is directed at 15 year old science learners and not at all children in the widest meaning of the word. In the adapted model I choose to look closer at four attitudinal constructs that have all been measured by the ROSE research and have frequently been identified in the literature, as mentioned earlier in the literature review. These are:

- Learner perceptions of school science,
- Learner perceptions of science and technology,
- Learner perceptions of scientists, and
- Learner perceptions of scientific careers.

In the model which I have adapted to my study (Figure 3) I have changed ‘achievement related choices and performance’ to ‘willingness to engage in science related issues’ as used in the PISA definition of scientific literacy. As can be seen in the adapted model of achievement choices in Figure 3 the model contains a feedback loop. This indicates that a small difference in the willingness to engage in science related issues continues in the system and either reinforces the willingness to engage or reduces it in the next round.

I soon realized that the ROSE information regarding the learner perceptions of different attitudinal constructs to science was an important part of applying the adapted model but not sufficient for understanding the consequences and prerequisites of these perceptions within the context of the Icelandic learner. Therefore I constructed questions for group interviews in order to collect information about other important parts of the model. Some questions that required more personal information were addressed right after the interviews with a brief electronic questionnaire (described in Chapter 4.1.6). This included items intended to measure the learners’ expectation of success.

Within the limitations of my research I was not able to gather data about each construct. I realized that in addition to attaining information about the cultural milieu and learners perceptions (A and E respectively, Figure 3) I would be able to address Subjective Task Value and the learner expectations of success (I and J respectively, Figure 3), both of which influence what I have called ‘Willingness to engage in science related issues (K, Figure 3).

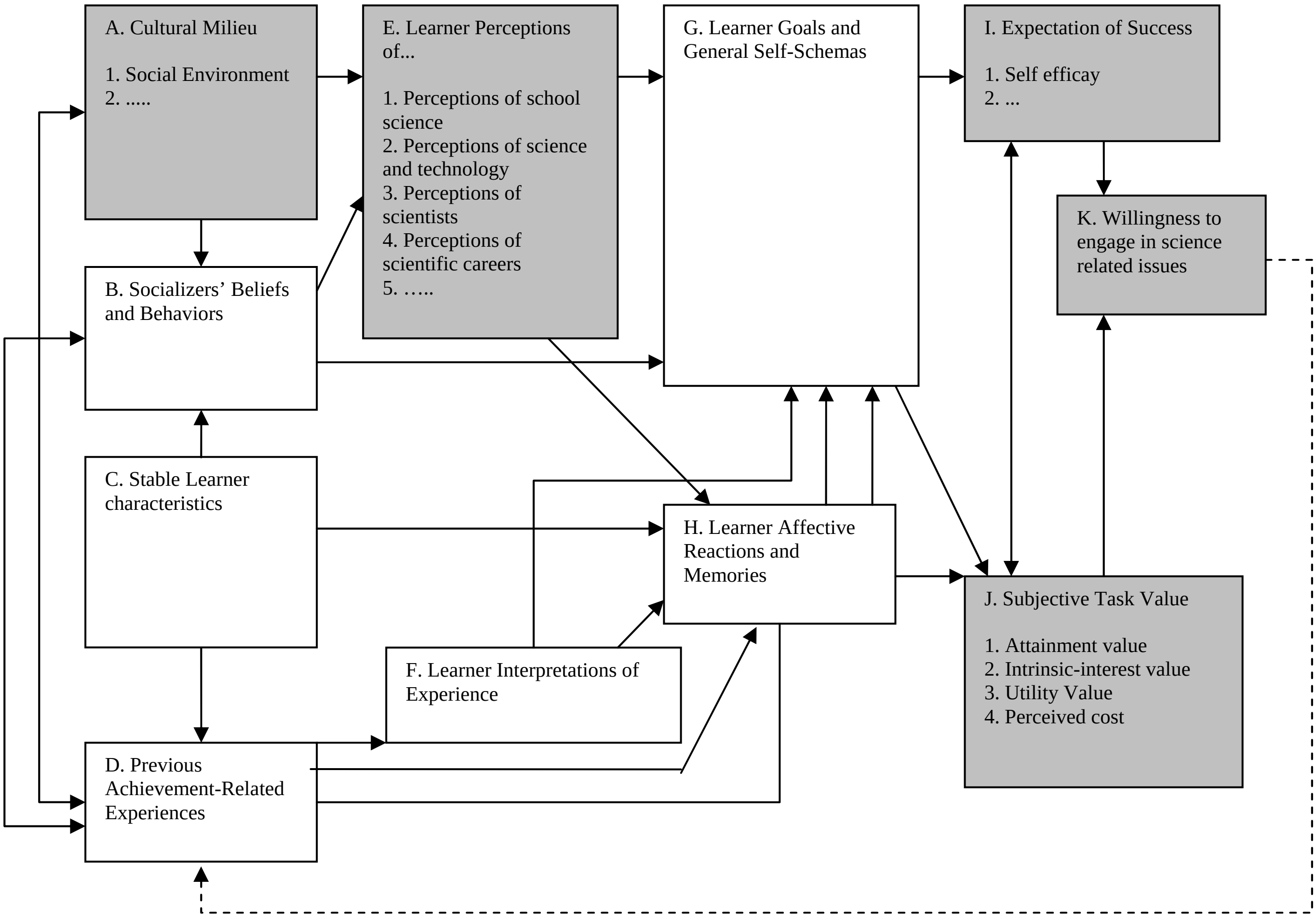

Figure 3 Adapted expectancy-value model of achievement choices in science related issues adapted from Eccles (2005). The grey boxes indicate constructs that will be addressed specifically in this research.

Expectation of success is a central construct in the Model of Achievement choices. As can be seen by its description in Chapter 3.3.1 the construct is complex. In order to obtain some information about the expectation of success from Icelandic learners that participated in the interviews I chose to use adapted items of academic self-efficacy at subject-specific measurement levels published in an article on self-concept and self-efficacy written by Bong and Skaalvik (2003). Due to the limited scope of my research I will not go into detailed description of the concept of self-efficacy in this paper and therefore instead refer to Bong and Skaalvik (2003) who refer to Bandura's formal theoretical definition of self-efficacy from 1977:

> *Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments… Such beliefs influence the course of action people choose to pursue, how much effort they put forth in given endeavors, how long they will persevere in the face of obstacles and failures, their resilience to adversity, whether their thought patterns are self-hindering or self-aiding, how much stress and depression they experience in coping with taxing environmental demand, and the level of accomplishments they realize* (Bandura,1977,in Bong & Skaalvik, 2003).

Self-efficacy is presumed to explain and predict one’s thoughts, emotion and action. Eccles (2005) does not include self-efficacy as an individual construct in the model of achievement choices. I interpret the formal theoretical definition of self-efficacy as included in the interaction between construct I ‘Expectation of Success’ and J ‘Subjective Task Value’ and have furthermore chosen to fit my subject-specific measurement of self-efficacy within construct I ‘Expectation of Success’ (see Figure 3). The items chosen for measurement are described in the Chapter 4.1.6.

3.5 Summary and the research question

This research grew out of quantitative research developed by others and the suitable application of data from this reseach to a research question which interested me became a long process. The nature of the quantitative data called for a framework that could situate the learner perceptions of science related issues in relation to their willingness to engage in science related issues. As this kind of framework was not readily available in the research literature the search for a framework for the interpretation of the ROSE data from Iceland became a research question in itself.

After reading some of the relevant literature, the model of general expectancy value of achievement choices created by Eccles (2005) and colleagues was chosen for adaptation. The complexity of the model revealed the limited scope of the ROSE data in terms of predicting the learners’ willingness to engage in science related issues. However it also revealed the potential of measuring learner perceptions with the aim of improving science education. This included the importance of the socializers’ beliefs and attitudes, the cultural milieu, the learners’ affective reactions and memories, the STV and the learners’ expectation of success in the learners’ willingness to engage in science related issues. The adapted model therefore called for additional data so the learner perceptions measured by the ROSE data could be situated in the model with some level of validity.

In order to use the potential of the ROSE data in understanding the learners’ willingness to engage in science related issues I decided to consider the Icelandic ROSE data by applying the adapted model and I formulated the following research question:

> How do learner perceptions of science related issues relate to their willingness to engage in those issues and what do we know about these perceptions in the context of Icelandic learners?

4. Methodology

4.1 Questionnaire data

Most of the quantitative data used in this research was gathered by myself and two other student teachers at the Iceland University of Education (Gunnarsson, Haraldsson, & Stefánsson, 2003). The translation, data collection, sampling and coding followed a set of rules explained in detail in the ROSE handbook (Sjøberg, 2002). Pre-formatted Excel and SPSS files were used along with the ROSE codebook explaining the criteria for each variable. All documents that were needed to conduct the research were accessible on the ROSE website. In the following section I will give a short description of how the Icelandic data was gathered. A more detailed description of the data gathering in Iceland can be found in the data collection report on the ROSE website (ROSE, 2006). The methodological explanations referred to in this chapter are from the book *Introduction to Research in Education* (Ary, Jackobs, & Razavieh, 2002).

In Chapter 5.1 I use ROSE data from 29 countries. The quality of the data gathering procedures in each country depended on the professionalism of each participating researcher and the infrastructure available. The data collection methods of each country can be found in the data collection reports published on the ROSE website (ROSE, 2006). During my work as an assistant researcher in cleaning and comparing international ROSE datafiles some methodological questions often came up. These either led to correspondence with the local researcher where issues concerning the data were solved or in some cases to a rejection of national datasets. Of the 33 datasets I chose to use in this research, four were excluded because they did not meet standards of sampling and participation. These were the datasets of KwaZulu Natal (South Africa), Western Cape (South Africa), Cyprus and Egypt. The results from these countries are therefore not included in my analysis.

4.1.1 ROSE questionnaire

The questionnaire was divided into three parts and each of the three student teachers involved translated one part into Icelandic by using the English version (see appendix) and the Norwegian questionnaire available on the ROSE website (ROSE, 2006). The Norwegian question list was more useful as Norwegian is the closest related language to Icelandic apart from Faeroese. The three students read each other's translations, met and discussed the translations and a final version was sent to the supervisors Haukur Arason and Stefán Bergmann for approval. When final amendments had been done the questionnaire was considered ready to be sent out to the participants.

The parts of the ROSE questionnaire used in this research are sections B, F and G.

- Section B was presented as 26 statements that the learners evaluated on a 4 point scale from not important to important. These items were developed in an attempt to find out what the learners find important regarding their future jobs.

- The F and G items were presented as 32 statements (16 each) that the learners evaluated on a 4 point scale from disagree to agree. These items assessed the views and attitudes the learners have towards science and technology in society (section G) and what learners feel about the science and technology they have experienced in their schooling (section F) (Schreiner & Sjøberg, 2004).

These three sections consist all in all of 58 four point Likert-scale items. The use of four point Likert-scale items is very common in the social sciences and has been well documented. The ROSE developers choose to interpret the Likert-scale as an interval scale (Schreiner & Sjøberg, 2004). From now on Likert-scale items will be referred to as scale items.

4.1.2 Sample and population

As recommended by the ROSE organizers it was decided to invite at least 625 learners, one class per school, from the last year of compulsory schooling, to participate in the research. This age was targeted by the ROSE project leaders since learners at that age face important decisions on whether they want to engage further in science or science related issues in upper secondary school. In Iceland these were so called 10th graders or learners, most of whom turned 15 in year 2003. According to Statistics Iceland (2006) there were 4555 learners in 10th grade in Iceland in the academic year of 2002-2003 (the time of the data collection).

The Icelandic society is very homogeneous due to high social equity and low immigration. In an attempt to find factors that could distort the quality of the sample we came up with two things. Firstly, the Icelandic population can be divided roughly into the urban Reykjavik area[4] and a number of small villages around the coastline that depend on fishing, agriculture and small scale industry. In the 20th century Iceland experienced extensive migration to the capital area around Reykjavik. The development is ongoing and in the year of the data gathering 63% of the Icelandic population was living in Reykjavik or in one of the six municipalities surrounding it (see Figure 4). Secondly, we assumed that the difference in school size could affect the school environment and therefore distort our sample. Of the 187 schools in Iceland in 2003 there were 72 schools with less than 100 learners (Statistics Iceland, 2006).

In an attempt to make the sample as representative as possible for the Icelandic population of 10th grade learners we decided to make the sample more national representative by putting extra weight on medium sized schools from the urban area. This was done randomly by programming a script run in Excel[5]. One of our supervisors, Haukur Arason, helped us with the programming. Information about the school size and district were downloaded from the homepage of Statistics Iceland (2006). The program chose 33 schools from all around the country.

All the schools agreed to participate in the questionnaire. Of the 33 schools 30 sent the questionnaire back fully completed. To more or less fill up the 625 learners limit two 10th grade classes in two schools in the capital area were asked to fill out the questionnaire. These two schools were selected by convenience reasons as they were close to the Iceland University of Education. All in all we received 620

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[4] The capital Reykjavik and six adjacent municipalities

[5] Excel is a spreadsheet program written and distributed by Microsoft see http://www.microsoft.com/excel

questionnaires, 310 from girls and 310 from boys. The number of participants was 14% of all 10th grade learners in Iceland that year.

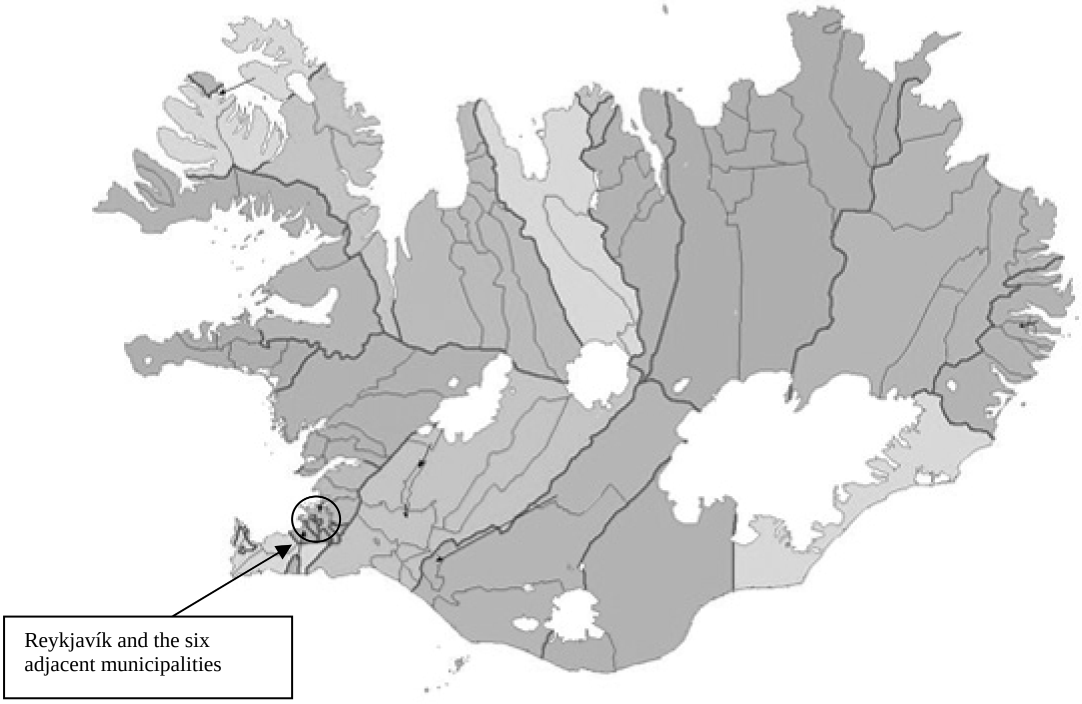

Figure 4 Municipalities of Iceland (NLSI, 2006). In year 2003 63% of the population lived in the capital Reykjavik or in the six adjacent municipalities.

4.1.3 Ethical issues

In accordance with Icelandic Act no. 77/2000 on The Protection of Privacy the planned research was reported to the Data Protection Authority (IDPA, 2006). When the report was acknowledged the principal of each of the 33 selected schools was contacted and asked if they would be interested in joining the ROSE research. Most of the principals were willing to participate but some were reluctant as their schools were already being bombarded with other research such as the PISA 2003 being arranged in all Icelandic schools at the time (see more about PISA in Chapter 2.4). The questionnaire was sent to the schools with instructions on how it should be administrated and how it should be sent back. A letter to parents giving them the opportunity for their child not to participate in the research was sent out by schools for the researchers. In an attempt to get data from as many countries as possible the organizers of the ROSE decided to limit the number of questions regarding the learners' personal background (Schreiner & Sjøberg, 2004). This made it simple to collect the ROSE data in Iceland without any known ethical dilemmas arising along the way.

4.1.4 Coding

The coding was done manually by the student teachers involved using the SPSS[6] 10.0 software package. Each questionnaire was given an identification number so it could

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[6] Originally, Statistical Package for the Social Sciences see http://www.spss.com

be traced in case of mistakes during the coding. After the coding the file was cleaned by reading the file manually and correcting obvious mistakes, such as illegal values, by comparing them to the original. Later during my master's studies I worked as an assistant researcher in the ROSE research. There I cleaned the Icelandic datafile a second time automatically by using a script I made in the SPSS program. The script was used to erase all possible illegal values from the datafile.

4.1.5 Reliability and validity

During this research I have encountered some theoretical and measurement issues about reliability and validity of measures of complex social and psychological constructs. Due to this I mainly refer to individual items from the ROSE questionnaire in my discussion and avoid merging results from individual items in an attempt to create social and psychological constructs. Perceptions of science related issues and willingness to engage in those issues are complex factors that are difficult to measure with high reliability and validity. Despite the limitation, the fact that the correlation between 41 of the 58 items from the ROSE questionnaire under evaluation and the Human Development Index was statistically significant and were substantial in size lends reliability to the national means of these 41 items.

4.1.6 Numerical data from other sources

The Human Development Index

The HDI index was developed in 1990 by a team of United Nations Development Programme (UNDP) researchers led by the Pakistani economist Mahbub ul Haq, and has been used and refined since 1993 by the UNDP in its annual report. The HDI is a composite of three basic components of human development: health, education and standard of living. Health is measured by life expectancy. Education is measured by a combination of adult literacy (two thirds weight) and mean years of schooling (one third weight). Standard of living is measured by purchasing power, based on real GDP per capita adjusted for the local cost of living (purchasing power parity). Table 1 shows the components of the Human Development Index as well as the index itself. I will not describe each variable in detail but for those interested a detailed description of the methods used in creating the HDI is available in the annual HDI report (UNDP, 2004).

Table 1 The Human Development Index of in 2003 of 29 countries participating in ROSE (UNDP, 2006).

HDI rank		Human development index (HDI) value 2003	Life expectancy at birth (years) 2003	Adult literacy rate (% ages 15 and above) 2003	Combined gross enrolment ratio for primary, secondary and tertiary schools (%) 2002/03	GDP per capita (PPP US$) 2003
High human development						
1	Norway	0.963	79.4	..	101	37,670
2	Iceland	0.956	80.7	..	96	31,243
6	Sweden	0.949	80.2	..	114	26,750
8	Ireland	0.946	77.7	..	93	37,738
11	Japan	0.943	82.0	..	84	27,967
13	Finland	0.941	78.5	..	108	27,619
14	Denmark	0.941	77.2	..	102	31,465
15	United Kingdom[7]	0.939	78.4	..	123	27,147
21	Spain	0.928	79.5	97.7	94	22,391
23	Israel	0.915	79.7	96.9	91	20,033
24	Greece	0.912	78.3	91.0	92	19,954
27	Portugal	0.904	77.2	92.5	94	18,126
36	Poland	0.858	74.3	99.7	90	11,379
38	Estonia	0.853	71.3	99.8	92	13,539
48	Latvia	0.836	71.6	99.7	90	10,270
57	Trinidad and Tobago	0.801	69.9	98.5	66	10,766
Medium human development						
61	Malaysia	0.796	73.2	88.7	71	9,512
62	Russian Federation	0.795	65.3	99.4	90	9,230
84	Philippines	0.758	70.4	92.6	82	4,321
94	Turkey	0.750	68.7	88.3	68	6,772
127	India	0.602	63.3	61.0	60	2,892
131	Botswana	0.565	36.3	78.9	70	8,714
138	Ghana	0.520	56.8	54.1	46	2,238
139	Bangladesh	0.520	62.8	41.1	53	1,770
144	Uganda	0.508	47.3	68.9	74	1,457
145	Zimbabwe	0.505	36.9	90.0	55	2,443
Low human development						
147	Swaziland	0.498	32.5	79.2	60	4,726
149	Lesotho	0.497	36.3	81.4	66	2,561

[7] England and Northern Ireland have the same HDI value.

In this research I assume that these three variables help to indicate an important and, most importantly, readily available indicator of the social environment in the participating countries. The HDI value of the 29 countries used for this comparison can be seen in Table 1. The HDI value is presented in descending order. The table also includes the rank number of each country. In all about 200 countries are evaluated. By definition the countries in the table are divided into three categories. Countries with HDI value higher than 0.8 are referred to as countries with high human development. Countries with HDI value higher than 0.5 and less than 0.8 are referred to as countries with medium human development. Countries with HDI value less than 0.5 are referred to as countries with low human development (UNDP, 2006).

Electronic questionnaire

An electronic questionnaire was made to collect what I considered to be sensitive personal background information. This was information I wanted to receive directly from each learner that participated in the interviews and therefore the learners were asked not to discuss the questions while answering them. Some of this information is not numerical by nature and the sample used to answer the questionnaire was not statistically representative for the population of 15 year old learners in Iceland. I programmed the data collection interface in a web-design software called FrontPage[8] and the data was submitted by the learner from the interface to a web based database management system called Access[9].

The interface consisted of four screens. The first screen appeared when the learners were asked to type http://natturufraedi.khi.is/vidhorf/ in the URL line of their internet browser. This screen contained one screen fill of text explaining the purpose of the data collection and informing the learner how the data was going to be used regarding the personal nature of the data being gathered.

[8] Microsoft Office FrontPage 2003 see http://www.microsoft.com/frontpage

[9] Microsoft Office Access 2003 see http://www.microsoft.com/access

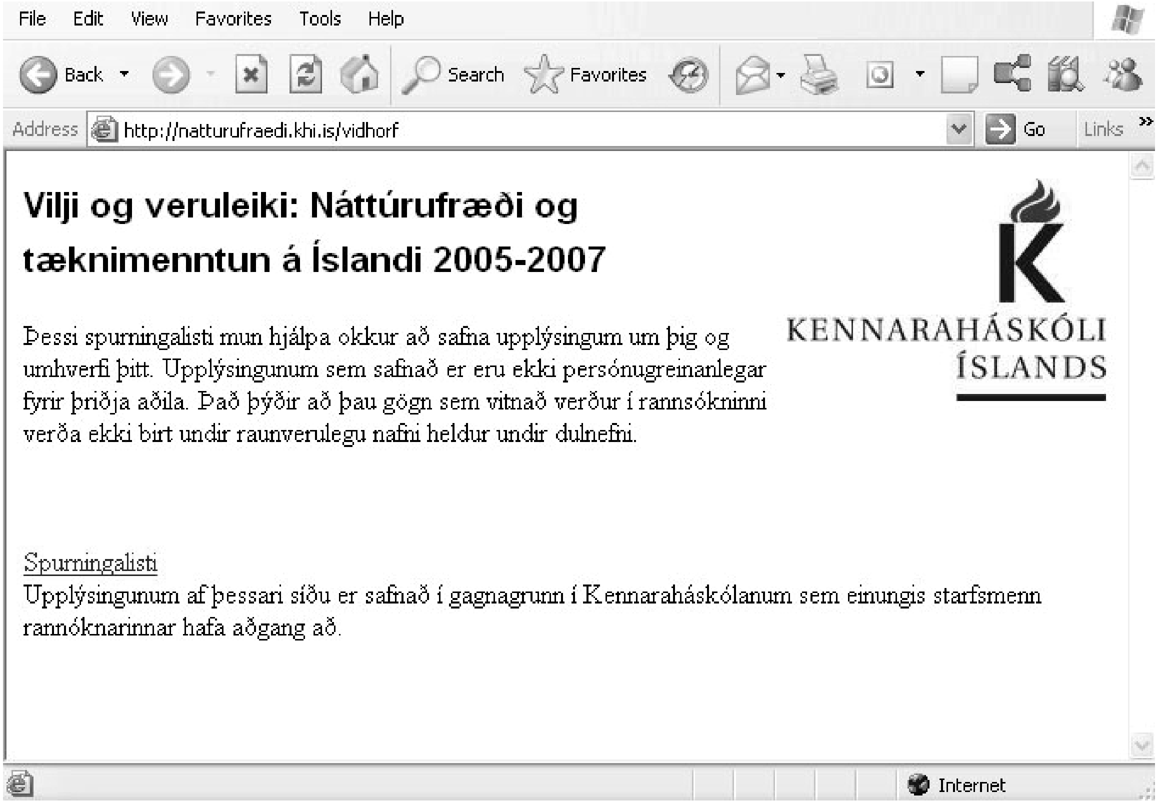

Figure 5 The first screen of the data collection interface. The webpage is viewed in Internet Explorer[10] 6.0.

To get to screen number two the learners had to click the word questionnaire which was blue and underlined as standard hyperlinks usually are. Screen number two contained two blank spaces for the learner to fill in a username and password. At this point I gave the learners their username and password. After clicking the submit button on the screen they continued to screen number three.

Screen number three was the main screen that contained the questions to be answered. The questions were divided in five parts which could by found by scrolling down the webpage. At the bottom of the webpage there was a submit button for submitting the data to the database.

The first part of the question list was called ‘help at home’ and contained two open item questions. The first one was: ‘How much help do you get from your parents when studying science?’ and the second one was: ‘Why do you get much/little/average help from your parents?’

The second part was called ‘friends’ and consisted of three open ended items. The first one was: ‘Are your friends interested in science related issues?’ The second one was: ‘What science related issues are they interested in?’ and the third one was: ‘Why or why not are they interested in these issues?’

The third part was called ‘self-evaluation’ and consisted of two open-ended items and two self-efficacy constructs represented with seven, five point scale items and three,

[10] Microsoft Internet Explorer see http://www.microsoft.com/windows/ie

five point scale items. The first open-ended item was: ‘How are you doing in school science?’ The second open ended item was: ‘Why do you think so?’ The first seven scale items (see Figure 6) were to measure so called subject specific self-efficacy (see discussion about self-efficacy in Chapter 3.4).

How confident are you that you can…

	not confident				very confident
pass science at the end of this term?	☐	☐	☐	☐	☐
pass science at the end of this term with a grade better than a 5?	☐	☐	☐	☐	☐
pass science at the end of this term with a grade better than a 6?	☐	☐	☐	☐	☐
pass science at the end of this term with a grade better than a 7?	☐	☐	☐	☐	☐
pass science at the end of this term with a grade better than an 8?	☐	☐	☐	☐	☐
pass science at the end of this term with a grade better than a 9?	☐	☐	☐	☐	☐
get 10 in science at the end of this term with a grade better than a?	☐	☐	☐	☐	☐

Figure 6 Items used to measure subject specific self-efficacy. Adapted from Bong and Skaalvik (2003).

The last three scale items were used to measure so called task-specific self-efficacy (see Figure 7). As my research developed I decided to sharpen the focus on the learner perceptions of science related issues (described in Chapter 5.2). Therefore I did not find it useful to raise the discussion about expectation of success to a higher level by introducing more than one measurement of self-efficacy. Due to this reason the results of the task specific measurement of self-efficacy are not presented or discussed in this thesis although they are available in the dataset. Further information about the measurement of self-efficacy can be found in Bong and Skaalvik (2003).

How confident are you that you can…

	not confident				very confident
use the concepts work, energy and power and describe the relations between them?	☐	☐	☐	☐	☐
work with concepts like power, pressure, buoyancy and mass and relate the knowledge to examples from daily life?	☐	☐	☐	☐	☐
work with simple calculations related to Newton’s second law?	☐	☐	☐	☐	☐

Figure 7 Items used to measure task specific self-efficacy adapted from Bong and Skaalvik (2003).

The fourth part of the question list was called ‘Books at home’. The purpose of that part was to gather information that could shed light on the social standard of the learners’ families. This was a copy of item J in the ROSE questionnaire (see appendix). Due to the focus on learner perceptions and the amount of data already obtained this data was not studied further in this research.

The last part of the question list was called ‘Information about me’ and contained items that were used to obtain information about name, school, age, telephone of parent or guardian, e-mail address and MSN-address[11]. This part also included the yes/no item ‘It is ok to contact me by e-mail or on MSN if any questions arise during the interview analysis.’. The opportunity of contacting the learners via chat or e-mail was not used in the analysis of this research but remains an opportunity for possible follow-up research.

After pressing the submit button the fourth, and last, screen of the data collection interface appeared. This screen contained two sentences expressing the researchers’ gratitude towards the learners for their participation.

All in all the use of the electronic questionnaire was successful. The learners showed immediate interest and answered it without much help in less then ten minutes. All the learners were positive about being contacted at later stages and all the seventeen learners had an MSN address and an e-mail address they used regularly.

4.2 Interview data

4.2.1 Interview questions

In the search for a suitable interview protocol I drew on the experience of other researchers at the Iceland University of Education as well as reading a number of research articles where qualitative methods had been used for similar purposes (see Chapter 2). After evaluating the pros and cons in a methodological context I chose the form of a one hour long semi-controlled group interview with six participants, three girls and three boys. Such an interview requires (though this depends on the participants) approximately ten well formulated questions together with some keywords that can be used when the discussion stops. As a framework for my interviews I adapted questions used in recent research of secondary school pupils' perceptions of science and engineering in the United Kingdom (Bevins, Brodie, & Brodie, 2005).

[11] Used for instant messaging on MSN messenger see http://messenger.msn.com

The following questions were formulated and used as guidelines during the interviews:

Research question:

- How do learner perceptions of science related issues relate to their willingness to engage in those issues and what do we know about these processes in an Icelandic learners' context?

Interview questions

1. What does the word school science mean? (what/why; what do you see before you?)
2. What is a typical science class? (how do you like school science; why/why not; discuss reasons; teaching – good and bad; possibilities for improvement; the use of ICT)
3. What do you bring to your science classes? (not much/much; experience; interest; knowledge; should that be considered in teaching)
4. What good do you get from engaging in school science in upper secondary school and university? (what kind of work is related to it?)
5. What do the words science and technology mean? (What do you see before you?)
6. Are you thinking about a career related to science and technology? (why/why not; discuss possible reason; influences; possibilities for improvement)
7. Do you know a scientist personally? (member of the family; someone in the society; different types of work; what is science and technology education?)
8. How important do you think it is to be able to communicate with specialists within science and technology? (not/very; why; role models)
9. What information do you get about possible careers within science and technology? (when; from whom; information; good or bad; influences; possibilities for improvement)
10. What do you think about science and technology in general? (knowledge and use; how does knowledge emerge; Icelandic industry; Icelandic high-tech companies; science and technology in the media)
11. If you could change something in school science what would it be?

The protocol was tested and discussed with one fifteen year old male learner before the actual interviews were conducted. This pilot interview revealed that some of the questions were hard to understand due to the words used. I rephrased these questions before the actual interviews.

4.2.2 Sample and population

The choice of participants to the interviews was not random. As described in Chapter 3.2 I participated in the research project *Intentions and reality* at the Iceland University of Education in the beginning of year 2006. The choice of learners was a purposive sample in relation to other research within the project. A part of the *Intentions and reality* research is aimed at science teachers at the lower secondary level (Macdonald, 2006). After getting the necessary approval I asked three of these teachers to select six learners, three girls and three boys, from their class for a group interview aimed at improving science teaching. My request was that the learners would be relatively good science learners that could consider science as a study trajectory in upper secondary school. In addition to that I asked the teachers to choose learners that were not shy and therefore willing to express their opinion. The practicality of choosing these learners was the possibility of reusing the data for comparing the profiles of the teachers' and learners' involved in other parts of the *Intentions and reality* research.

The time and place for the interviews was decided in cooperation with the teachers, first by e-mail and then confirmed by a telephone call. Many compromises were made to the sample due to practical reasons before the final group from each of the three schools was ready. The final participants can be seen in Table 2. On arrival in School A one of the boys that was supposed to participate in the interview was sick and no other could step in at such a short notice. Due to this only two boys and three girls participated from School A. School B had no 10th grade so I decided to get learners from 9th grade instead. On arrival in School C more boys then girls were willing to participate in the interview. Therefore four boys and two girls participated in the interview in School C. All in all seventeen learners participated in the interviews nine boys and eight girls.

Name	School	Gender
Maja	School A	F
Ýr	School A	F
Ósk	School A	F
Ari	School A	M
Jón	School A	M
Þóra	School B	F
Karl	School B	M
Böðvar	School B	M
Árni	School B	M
Kolla	School B	F
Íris	School B	F
Þórunn	School C	F
Tinna	School C	F
Tumi	School C	M
Stefán	School C	M
Þórarinn	School C	M
Palli	School C	M

Table 2 Participants in the group interviews.

4.2.3 Ethical issues

The data collected during the interviews was collected under the umbrella of the *Intentions and reality* research described in Chapter 3.2. In accordance with Icelandic Act no. 77/2000 on The Protection of Privacy the research was reported to the Data Protection Authority (IDPA, 2006). Due to the already established network in the participating schools permission to collect additional data from the learners was straightforward to obtain. A letter giving the parents the opportunity for their child not to participate in the research was sent to the teachers and they sent it home with the learners interested in participating. The participants provided some personal information such as their names and e-mail addresses in the electronic questionnaire (see Chapter 4.1.6). This was done so they could possibly be contacted at later stages during the data analysis. The confidentiality of personal information that was collected in the electronic questionnaire and the interviews placed ethical duties on me as a researcher. This included that I had to bear in mind at all times that the use of the information that was being gathered could not be used against the participants of the research in any way. Due to this all the information that is published from the qualitative data has been critically evaluated and is published under fictitious names. The interview transcripts, recordings and the database containing the information are only accessible to the *Intentions and reality* research team in the Iceland University of Education with access restricted to the researchers directly involved in the research.

4.2.4 The interview process

The pilot interview took place on the 23rd January in the living room of the learners' home. The interview in School A took place at the school on the 24th January in the learners' social room. The interview in School B took place on the 7th February at a round table in the teachers' meeting room. The interview in School C took place on the 16th February in an open work space in the school library. All the interviews were taken within normal school hours just after or before lunch except the pilot interview which was taken in the evening. All the interviews were recorded using a Sony Mini-Disc recorder[12]. Each recording begins with me stating the location, time and participants of the interview.

A colleague of mine Marín Tumadóttir assisted me during the interviews. She sat close by with a laptop computer and typed the first letter in the first name and the beginning of the sentence of the person that was talking at the time. This was done to simplify the transcription from the voice recordings during later stages. At the beginning of the interview my colleague and I said hello to the learners and introduced ourselves as researchers with the aim of improving school science. After that my colleague resigned from the discussion and concentrated on the transcription. We also reviewed the interview together afterwards.

I started all the interviews with a little chat (2-3 minutes) about trivial things that I knew the learners would find socially acceptable to talk about. For example, the newly crowned winner in the Icelandic national finals of the Eurovision Song Contest which was very popular among young people at the time. This provided a relaxed atmosphere to start the discussion. During this chat I asked the learners to take a sheet of A4 paper and pen, which we brought with us, and write their name on it. Then I asked them to fold it so I could see their names at all times during the interview. After that I usually began my sentences by saying their names. This created a personal atmosphere in the interviews as well as making the transcription from the voice recording much easier afterwards.

To my great relief all the groups were eager to answer and discuss the questions I had to ask. On the few occasions, when the discussion slowed down, I repeated something that had just been said to keep the discussion going without affecting the point being

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[12] For additional information see http://www.sony.com

made by the learners. Some learners talked more than others. When I felt that some learner was not getting the opportunity to participate in the discussion I intervened in the discussion and asked for the opinion of that specific learner. The direction the discussion took in each group was unpredictable. Some of the questions were answered together and one question often came as a natural continuation of another. Due to this the guidelines was not followed in the numerical row as presented in Chapter 4.2.1 but rather in an order of convenience. The only questions that were asked at the same time in all the interviews were the first and the last question.

Understanding science is more than just knowing the meaning of particular words and terms, it is about making meaning through exploring how these words and terms relate to each other. This became evident when constructing the protocol used in the interviews. In Icelandic as well as in many other North Germanic languages school science in the primary and secondary level is referred to as the ‘study of nature’ (Icelandic: náttúrufræði) which includes the subjects of physics, chemistry, geology and biology. The words science and technology on the other hand are easier to translate (Icelandic: vísindi og tækni). The meaning of these particular words and the relation between them was assessed specially. To make the words an object which we could discuss I made two plastic boards with the terms printed on one side. During the interviews I introduced these boards one at a time before presenting them both to get out the relation between them. These objects also functioned as a trigger, starting the discussion and holding it within the borders of school science and science and technology as the objects maintained visible during the whole interview.

After approximately 30 minutes of discussing science related issues I took a break and offered the learners and my colleague some refreshments (a bottle of soda and a candy bar) that we brought to the interview. This was done to relax the atmosphere and reward the learners in some way for their unselfish efforts. The break was recorded along with the interview as all of the groups continued to talk about science related issues during the so-called break. When approximately 60 minutes had passed I ended the interview by thanking the learners for their participation, reading the time when the interview ended and turning the voice recorder off. After that I asked the learners to move to the nearest computer room to fill out the electronic questionnaire.

4.3 Analysis

4.3.1 Using the questionnaire data

The analysis of the questionnaire data was primarily done using the SPSS software package. In some cases statistical tables were first produced in SPSS and then exported to Excel for further analysis. In my analysis I have mainly used four statistical concepts: range, arithmetic average, standard deviation and Pearson’s product moment coefficient of correlation (Ary, Jackobs, & Razavieh, 2002):

Range

Range is the difference between the highest and the lowest score in a distribution. This is used when interpreting the extent of the difference between the highest and the lowest national mean of an item.

Arithmetic average

The average is the sum of all the values in the distribution divided by the number of cases. The items under investigation are presented on a scale from disagree-agree, not important-important and not confident-confident. I choose to interpret these scales as interval scales and therefore the arithmetic average is an appropriate statistic to measure the central tendency of the dataset.

Standard Deviation

To identify the variability in the distribution of scores I use the standard deviation score which is the measure of the extent to which an individual score deviates from the mean of the distribution. This has helped me to detect items that stand out due to the distribution of their scores. An example could be the response to item F6 ‘I think everybody should learn science at school’ where individual scores deviated the most from all the means in section F. The distribution can be seen in Figure 9 on page 53.

Pearson’s Product Moment Coefficient of Correlation

Pearson’s Product Moment Coefficient of Correlation is defined as the mean of the z-score products. (The z-score being a standard score indicating how far a score is above or below the mean score in terms of standard deviation units)

Understanding correlations

Pearson’s Product Moment Coefficient of Correlation indicates both the direction (negative or positive) and the strength of a relationship between variables. The results in value range from -1.00 to + 1.00. A correlation coefficient of -1.00 indicates a perfect negative relationship, a value of +1.00 indicates a perfect positive relationship, and the midpoint of this range, 0, indicates no relationship at all. Many correlation coefficients exist but as we are dealing with an interval scale the Pearson’s Product Moment Coefficient of Correlation is the one most commonly used. I have measured the direction and the strength of the relationship between the human development level of a country and the national mean of the items in section F, G and B of the ROSE questionnaire. The interpretation of the coefficient has to be done with great care as misinterpretations are easy to make. When interpreting the correlation coefficient these points have to be in mind (Ary, Jackobs, & Razavieh, 2002):

1. *Correlation does not necessarily indicate causation.* When the variables are found to be correlated, this indicates that relative positions in one variable are associated with relative positions in the other variable. It does not necessarily mean that changes in one variable are caused by changes in the other variable. For example I have found a high negative correlation between some attitudes towards science education and the Human Development Index (HDI) (see Chapter 5.1). This tells us that learners in a high HDI country will probably have more negative attitudes towards science education then learners in a low HDI country. But we cannot say that high a Human Development Index score causes negative attitudes towards science education. Reasons for the negative attitudes amongst some countries may result from other causes, such for example a higher ego and self-actualization need among the high HDI learners.

2. *The size of correlation is in part a function of the variability of the two distributions to be correlated.* Restricting the range of the scores to be

correlated reduces the observed degree of relationship between two variables. To use the same example as before the higher HDI score a country has the more probable it is that a pupil from that country has some negative attitudes towards science education. This statement is true for the population at large, where there is a wide range of scores. However, within a group of countries, for example the Nordic countries whose HDI scores are all high, there may be little or no correlation between HDI scores and negative attitudes towards science education, because the range of HDI scores is restricted. The variety of the ROSE participating countries is therefore a benefit to this kind of research.

3. *Correlation coefficients should not be interpreted in terms of percentage of perfect correlation.* Because correlation coefficients are expressed as decimal fractions, people who are not trained in statistics sometimes interpret correlation coefficients as a percentage of perfect correlation. An r of around -.80 does not indicate 80 percent of a perfect negative relationship between two variables. A way of determining the degree to which you can predict one variable from the other is to calculate an index called coefficient of determination. The coefficient of determination is the square of the correlation coefficient. It gives the percentage of variance in one variable that is associated with variance in the other. For example in our case the correlation between the HDI value in the ROSE countries and the agreement rate to statement 'F14. I would like to become a scientist' was r = -0,95. This means that approximately 90% of the variance in the HDI score is associated with the variance in the agreement rate. All figures in this thesis that indicate the correlation between two variables have the coefficient of determination printed on the figure.

4. *Avoid interpreting the coefficients of correlation in an absolute sense.* When interpreting the degree of correlation it is necessary to keep in mind the purpose for which it is being used. In the case of my research the purpose of it is to present empirical findings to stimulate a discussion about the perceived relevance of science and science education internationally. Therefore a $\pm$0,5 coefficient of correlation might be satisfactory in many cases. Different purposes might require a different degree of relationship. The coefficient of $\pm$0,5 is not an absolute value with the same implications in both cases.

The Pearson R as a measure of relationships independent of sample size is a form of effect size. That is to say, it is a technique to assess the magnitude of the relationship between two variables. Ary, Jackobs, & Razavieh (2002) refer to Cohen (1998) who has suggested the following conventions for the effect sizes of correlations:

r = 0.1 small effect size

r = 0.3 medium effect size

r = 0.5 large effect size

Many correlation coefficients found in the behavioral sciences are of this magnitude:

> *For example, correlation coefficients between personality tests and real life criteria typically fall around .30. Correlations within a single variable, such as two measures of the same thing, often exceed .50. Correlations of competing tests of spelling proficiency are typically about .80. Correlations between*

equivalent forms of a single test are often in excess of .90. However, correlations between different variables in the behavioral sciences rarely approach that level. As Cohen (p. 81) says, 'Thus, when an investigator anticipates a degree of correlation between two different variables 'about as high as they come' this would by our definition be a large effect .50 (Ary, Jackobs, & Razavieh, 2002).

4.3.2 Using the interview data

The pilot interview was not transcribed or analyzed as it was merely meant to function as training and for testing the interview questions. The first two interviews were transcribed by me in the days after the interviews were conducted. I transcribed the interviews directly into the software used for the coding and analysis. The third interview was transcribed by a professional working for the *Intentions and reality* research (see Chapter 3.2) and imported into the software from a regular text file. The software I used in the beginning was qualitative data analysis software called NVivo 2[13]. During the research the Iceland University of Education decided to upgrade its Nvivo 2 software license and purchased a newer version of the software called NVivo 7[14]. This version was used at later stages during the research. During the transcription I simultaneously coded the themes that emerged from the text into the research database of the software. When the transcription was done I read through the transcript once again and coded more new themes that emerged from the text. Thereafter I merged and simplified the coding to eight themes that could be situated in the adapted model of achievement related choices. These themes are the four perceptions of science described in Chapter 5.2 and the four components of the subjective task values described in Chapter 5.3.2. When the coding was done I was able to use the software to compare and print out reports about individual learners or groups of learners in the light of the themes that had emerged from the data. The use of the qualitative data analysis software became useful when answering questions that came up during later stages of the research.

When writing about learners I frequently refer to learners in general although only some of the learners actually mentioned the specific issues under consideration. When this is done it is because during the interviews I sometimes had the distinct feeling that learners indicated their consent indirectly by either nodding their heads or not being provoked by the issue being discussed by other learners. In the few cases when all the learners indicated on common stand verbally I specifically write 'all the learners' instead of 'the learners'.

4.3.3 Connecting the two

As described in Chapter 3.5 the complexity of studying learners' willingness to engage in science related issues revealed the limited scope of the ROSE data in addressing such questions. This called for additional data so the learner perceptions measured by the ROSE data could be interpreted. This was done by developing the interview protocol for three group interviews. One purpose of the qualitative interview data that was gathered in January and February 2006 was to describe the

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[13] Formerly NUD*IST 'Non-Numerical Unstructured Data Indexing Searching and Theorizing' see http://www.qsrinternational.com

[14] The latest descendent of the NVivo 2 and N6 software see http://www.qsrinternational.com

meaning and the context of the perceptions by fifteen year old learners even though the quantitative measurements were made three years earlier. The qualitative nature of the data as well as the three year difference makes it difficult to make any assumptions about the population that originally participated in the ROSE research. None the less I found it meaningful to use the data from the interviews when interpreting the ROSE data. This is due to the threefold division of attitude research discussed in Chapter 2.4 that is: *'what the learners know about the topic, how they feel about what they know and how this affects their behavior'*. The interviews of the three fifteen year old groups from 2006 in my opinion provided a useful tool in possible interpretations of the data from the nationally representative ROSE sample of 2003. Due to the difference of the two samples the two datasets are consciously held apart when presenting the results and the discussion in Chapter 5. This is done to able the reader to draw an independent assumption of the credibility of the two methodological approaches. The discussion however integrates the key findings that emerge from both datasets.

5. Results

5.1 Social environment

The cultural milieu is important in the adapted model used in this research as can be seen in Figure 3. The cultural milieu shapes the ‘socializers’ beliefs and behaviors’ and together they create the image on which the learners base their perception of science related issues. As collecting information about the cultural milieu of a society is a complex process I decided to use social indicators that could provide information about the social environment of the learner. It is my assumption that the social environment is a part of the cultural milieu (see Figure 3).

The aim of this chapter is not to describe the Icelandic learners’ cultural milieu in any detail. The results in the chapter aim to confirm the importance of the social environment when referring to the learner perceptions of science related issues. This is done by relating the outcomes of sections B, F and G from the ROSE questionnaire to the Human development index (HDI) discussed in Chapter 4.1.6.

In an attempt to quantify differences in social environment I used the 2003 United Nations Human Development Index (HDI) (see Chapter 4.1.6) and results from the ROSE questionnaire (see Chapter 4.1.1). I calculated the correlation coefficient between the HDI value of 29 participating countries of the ROSE research and the respective national means from 58 scale items from the ROSE questionnaire. All the 58 items were intended to shed light on children’s perceptions of science, scientists and the science classroom and future job priorities (see Chapter 4.1.1.).

The correlation calculations showed that 41 of the 58 items had significant correlations at the 0.01 level (Sig. 2-tailed) to the HDI (see shaded items in Table 3).

Table 3 Correlation between national means of the ROSE items and the Human Development Index 2003 (HDI). The shaded items show 41 items that had significant correlations at the 0.01 level (Sig. 2-tailed) to the HDI. The items are in descending order according to the correlation coefficient.

All items from section B, F and G of the ROSE questionnaire	**Pearson's R (+1)**
B12. Having lots of time for my friends	0,88
F1. School science is a difficult subject	0,65
G10. Science and technology are the cause of the environmental problems	0,29
B17. Having lots of time for my family	0,24
B23. Having lots of time for my interests, hobbies and activities	0,18
B13. Making my own decisions	0,16
B3. Working with animals	0,02
B20. Earning lots of money	0,00
G12. Science and technology benefit mainly the developed countries	-0,03
B19. Working at a place where something new and exciting happens frequently	-0,05
B16. Working with something that fits my attitudes and values	-0,09
G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	-0,21
G16. Scientific theories develop and change all the time	-0,21
B18. Working with something that involves a lot of traveling	-0,23
B15. Working with something I find important and meaningful	-0,29
B14. Working independently of other people	-0,33
B1. Working with people rather than things	-0,39
B26. Working as part of a team with many people around me	-0,41
B9. Using my talents and abilities	-0,44
G3. Thanks to science and technology, there will be greater opportunities for future generations	-0,62
B8. Working artistically and creatively in art	-0,65
B24. Becoming 'the boss' at my job	-0,66
B6. Building or repairing objects using my hands	-0,67
B21. Controlling other people	-0,68
B25. Developing or improving my knowledge and abilities	-0,72
B5. Working with something easy and simple	-0,73
G11. A country needs science and technology to become developed	-0,73
B10. Making, designing or inventing something	-0,74
G14. We should always trust what scientists have to say	-0,74
G9. Science and technology are helping the poor	-0,74
G1. Science and technology are important for society	-0,75
F10. School science has increased my curiosity about things we cannot yet explain	-0,76
G6. The benefits of science are greater than the harmful effects it could have	-0,76
B2. Helping other people	-0,77
F3. School science is rather easy for me to learn	-0,79
B22. Becoming famous	-0,80
G4. Science and technology make our lives healthier, easier and more comfortable	-0,81
G7. Science and technology will help to eradicate poverty and famine in the world	-0,82
G5. New technologies will make work more interesting	-0,82
B4. Working in the area of environmental protection	-0,82
F2. School science is interesting	-0,82
B11. Coming up with new ideas	-0,83
G15. Scientists are neutral and objective	-0,84

F9. School science has made me more critical and skeptical	-0,84
F13. School science has taught me how to take better care of my health	-0,85
F6. I think everybody should learn science at school	-0,85
F8. I think that the science I learn at school will improve my career chances	-0,86
G13. Scientists follow the scientific method that always leads them to correct answers	-0,86
B7. Working with machines or tools	-0,86
F11. School science has increased my appreciation of nature	-0,86
F4. School science has opened my eyes to new and exciting jobs	-0,86
G8. Science and technology can solve nearly all problems	-0,87
F12. School science has shown me the importance of science for our way of living	-0,89
F7. The things that I learn in science at school will be helpful in my everyday life	-0,89
F5. I like school science better than most other subjects	-0,90
F16. I would like to get a job in technology	-0,92
F15. I would like to have as much science as possible at school	-0,93
F14. I would like to become a scientist	-0,95

Of these 58 items only two items had a significant *positive* correlation with the HDI. This was item B12 ‘Having lots of time for my friend’s (not important/important) and item F1 ‘School science is a difficult subject’ (disagree/agree). This means that learners from countries with high human development indicated a higher rate of importance and agreement towards these two statements than learners from countries with low human development.

At the same time 39 other items had strong negative correlation to the HDI. As an example of a strong correlation it is interesting to look at item F14 ‘I would like to become a scientist’ which had the strongest negative correlation of all the items (R= -0.95). As can be seen in the scatter diagram in Figure 8 agreement with the statement in each country (indicated by the national mean) decreases with increasing indicators of human development.

Of the 58 items in Table 3 only 17 items did not have a significant correlation at the 0.01 level (Sig. 2-tailed) to the HDI. 13 of these items were from section B ‘My future job’ and the remaining 4 from section G ‘My opinions about science and technology’. All of the items in section F ‘My opinions about science and technology’ had a significant correlation to the HDI (see Chapter 4.1.1 and Appendix for more information about the ROSE questionnaire).

It seems like items that have to do with school science have a stronger tendence to have a significant correlation to the HDI than items that have to do with the learners’ future job. Interpreting correlations like these is hard (see Chapter 4.3.1).This could be interpreted in the sense that the learner perceptions of school science differ in relation to their social environment. At the samt time many of the items that have to do with the learners’ future job do not seem to differ in relation to their social environment. These results are interesting and call for further research.

The aim of this chapter is to confirm the importance of the social environment when referring to the learner perceptions of science related issues. This I intend to do by focusing on the previously mentioned 41 items that showed a significant correlation at the 0.01 level (Sig. 2-tailed) to the HDI.

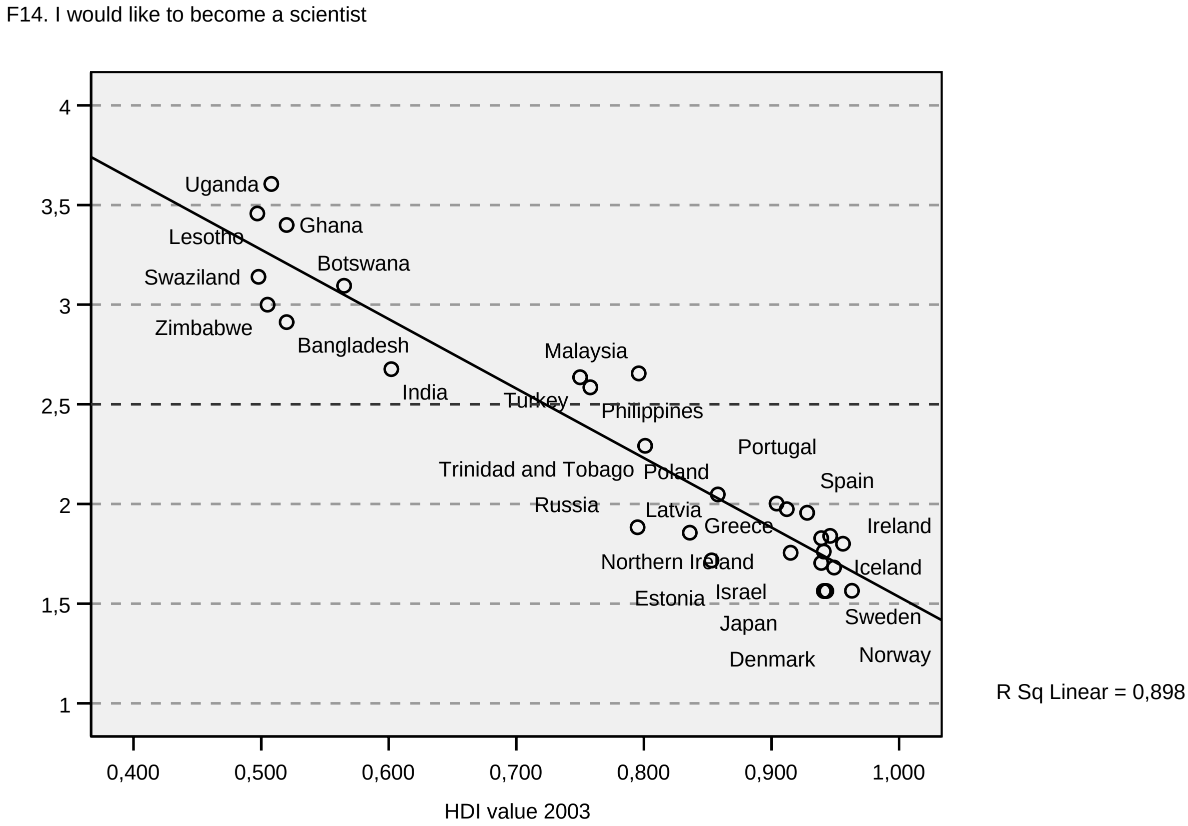

Figure 8 Correlation between the national means of F14 'I would like to become a scientist' and the Human Development Index value.

According to Ary, Jackobs, & Razavieh (2002), the importance of the numerical value of a particular correlation may be evaluated in three ways:

1. according to its absolute size and predictive utility,
2. in relation to other correlations of the same or similar variables, and
3. in terms of statistical significance

Firstly I considered the value according to its *absolute size and predictive utility*. One can see in Table 3 that the magnitude of the correlation between the ROSE data and the Human Development Index is large in a majority of the ROSE items under consideration. If Cohen's (1998) conventions are used (see Chapter 4.3.1) many of the items have a large effect size of correlation.

Secondly I considered the value in relation to other *correlations of the same or similar variables*. As pointed out before the variables under consideration can be considered similar as they all have to do with the learner perceptions of science related issues and many of these variables have a large effect size of correlation.

Furthermore similar studies on children's attitude towards education have indicated similar trends (although weaker correlation) in datasets with less cultural diversity. Data from TIMSS 2003 has been shown that pupils from countries with a low standard of living appreciate school subjects and schooling in general more than pupils from countries with high standards of living (Grønmo, Bergem, Kjærnsli, Lie, & Turmo, 2004). Attitudes towards mathematics have a stronger negative correlation to the HDI than with achievement. The correlation coefficient was -0.75 for the 7 statements used to measure attitudes towards mathematics in TIMSS 2003. These seven statements (my own translation from Norwegian) have many similarities to the ROSE items used in this thesis:

- I could have more mathematics at school
- I like learning mathematics
- I think learning mathematics will help me in my everyday life
- I need mathematics to learn other subjects
- I need to do well in mathematics so I can choose the education I want the most
- I would like to have a job where I can use mathematics
- I have to do well in mathematics so I can get the job I want

Data from PISA 2003 has shown similar results in statements (my own translation from Norwegian) that have to do with an interest in mathematics:

- I like books about mathematics
- I look forward to my mathematic lessons
- I work with mathematics because I like it
- I am interested in the things I learn in mathematics

The correlation coefficient between the interest statements and the HDI is strong negative according to the PISA 2003 data or -0.73 (Kjærnsli, Lie, Olsen, Roe, & Turmo, 2004). The outcome of this correlation furthermore backs up the strong correlation found in most of the items about learners perceptions of science related issues in my thesis. The fact that the correlation is stronger can well be explained by the difference in the statements and the cultural diversity of the ROSE data set.

Thirdly I looked at correlations in terms of statistical significance, according to Ary, Jackobs, & Razavieh (2002). The significance tests (2-tailed) show that all the top 41 correlation coefficients are statistically significant at the 0.01 level.

Together these three issues show that the national means of the previously mentioned 41 items were predictable when the level of human development was known and similarly the level of human development was predictable when the national means of the previously mentioned 41 items was known.

Without going into detailed description of each item it is statistically safe to assume that the difference in national means of the 41 ROSE items with significant correlation can largely be explained by factors measured by the HDI. What these factors are and how they affect the learner perceptions are questions which await further research. Assuming that these factors are all a part of the social environment it can be proposed that the social environment of learners, as measured by the HDI, is important in shaping the images of science related issues perceived by learners, in that society. This confirms the importance of the social environment when referring to learner perceptions of science related issues.

5.2 Learner perceptions

In this chapter I will try to shed some light on four factors that all are part of construct E ‘Learner perceptions of…’ in the adapted model (see Figure 3 on page 22) from Eccles (2005). As the interview data and the ROSE questionnaire complement each other I will try to use the data to describe Icelandic learner perceptions in some detail bearing in mind what learners know about the topic, how they feel about what they know and how this affects their behavior. As suggested by the model chosen for adaptation (see Figure 2 on page 15) special attention will be given to the learner perceptions of the socializers’ beliefs, expectations, attitudes and behaviors, gender roles and activity stereotypes and task demands.

5.2.1 Perceptions of school science

In the interviews when presenting the plastic board with the word ‘náttúrufræði’ (school science) learners immediately related it to objects that in their minds conceptualize nature. These where objects like animals, grass, the environment and biology. No connections were made to physics or chemistry by the learners. This connection to biology was so strong that when the learners were then asked to describe a typical science lesson, the first respondent, Jón, automatically assumed I was referring to biology:

> *Kristján: Well, how about we start with you now, how do you describe a typical science lesson?*
>
> *Jón: You mean biology?*

A typical science lesson sequence in the eyes of learners was described in three simple steps:

1. Reading at home.
2. Answering questions in class, in writing.
3. Discussing the answers.

Learners made a very clear distinction between biology on one hand and physics and chemistry on the other. Biology including more talking and discussion and the latter including more calculating and explaining.

Learners placed high demands on the teacher’s preparation. They demanded well prepared teachers preferably with well organized hand-outs. They wanted more teaching about less content and complained about not understanding all the content they had been through. Content outside the text-book or content that was not likely to appear on the upcoming national exams was not appreciated.

> *Ýr: Yeah we cover so incredibly much content and some of it not well at all. We should rather cover a bit less and study it better.*
>
> *Ari: Yes*
>
> *Kristján: Cover less material and study it better?*
>
> *Ýr: Yes like some of the things we have been studying hasn’t even been on the national exams.*
>
> *Ósk: Maybe one doesn’t always understand what one reads in the science textbooks*

Learners repeatedly mentioned practical work as a fun way to learn science. Practical work was seen as a welcome change in a dull school day full of textbook assignments. Learners who were used to the teacher only doing demonstrations of practical work showed great interest in doing the practical work themselves. Some of them even recalled hands-on activities during science lessons from two years earlier with great admiration and recalled the name of an old science teacher with respect in their voice.

Learners were asked about the role of ICT in the science lessons. They said they had not used ICT in science lessons other than for finding references for essays. When asked whether they thought that more ICT could make science more fun all agreed, all but Ari. He said that it was not a key issue. As I will come to later I think that Ari's subjective task value and expectation of success was so high that he simply saw no reason to inflict it with uncertain changes such as the introduction of an undefined increase of the use of ICT.

When asked about what profession they thought was related to school science all the girls and a majority of the boys mentioned the medical profession immediately and a couple of the boys mentioned engineering and computers later in the discussion.

When asked about if they had received any information about possible science and technology related careers, learners did not remember anything specific although they all admitted that they had been thinking about such careers. When I asked them directly about career counseling they remembered some interest surveys and said that they had a career counselor working at the school. They were especially looking forward to work visits which they undertake at the end of 10th grade. When asked of the importance of this and possible improvements, one of the 10th graders, Jón, mentioned that it could be nice to have them in 9th grade as well. Otherwise everybody emphasized that visits to workplaces were important and necessary and they would like to go more often. Also, that they would prefer going to workplaces rather then having work representatives visiting the classroom.

At the end of the interview I asked learners about what they would change if they were given the power to change something regarding school science. Everybody mentioned more practical work as the number one thing they would like to see change. They wanted fewer written assignments, better preparation on behalf of the teachers and more teaching of less content.

One of the girls from 10th grade, Ósk, and one from the 9th grade, Íris, indicated that school science and science and technology were not cool.

> *Kristján: As long as we are talking about this, how is this connected? Is this connected and then how? (showing two signs one with the word school science the other with the word science and technology)*
>
> *Silence*
>
> *Kristján: Ha ha, these are difficult questions, sorry*
>
> *Ari: School science is more in these subjects, biology*
>
> *Maja: The subject about life*
>
> *Ósk: This is all just formulas*
>
> *all: laugh*
>
> *Kristján: This is all formulas? (pointing at science and technology)*
>
> *Ósk: Yes. Just everything, both, just formulas you are always calculating.*

Furthermore, Ósk was the only one that did not admit that she thought science and technology was interesting. According to the electronic questionnaire these two girls where shown to have the lowest self-efficacy of the whole group that was interviewed.

Items that shed some light on what learners feel about the science and technology they have experienced in their schooling are found in Section F of the ROSE questionnaire (see 4.1.1 and Appendix). Learners answered the items by ticking a four point scale that ranged from disagree to agree. The mean of these sixteen items is presented in Table 4 in descending order of aggreement. The text that follows is a critical reflection of the results seen in the light of the interviews previously presented. All the means from this section of the ROSE questionnaire are presented in the table and a few are selected for a closer look due to their relevance to the interviews or special statistical anomalies.

Table 4 Means in descending order of agreement with statements about perceptions of school science from section F of the ROSE questionnaire.

My science classroom	Mean (1-4)	Std. Dev.
F2. School science is interesting	2,77	1,08
F3. School science is rather easy for me to learn	2,56	1,06
F6. I think everybody should learn science at school	2,52	1,22
F7. The things that I learn in science at school will be helpful in my everyday life	2,50	1,09
F8. I think that the science I learn at school will improve my career chances	2,49	1,10
F1. School science is a difficult subject	2,49	1,06
F10. School science has increased my curiosity about things we cannot yet explain	2,49	1,10
F12. School science has shown me the importance of science for our way of living	2,19	1,00
F4. School science has opened my eyes to new and exciting jobs	2,17	1,09
F11. School science has increased my appreciation of nature	2,16	1,05
F16. I would like to get a job in technology	2,16	1,10
F13. School science has taught me how to take better care of my health	2,04	1,00
F5. I like school science better than most other subjects	1,97	1,05
F9. School science has made me more critical and skeptical	1,93	0,97
F15. I would like to have as much science as possible at school	1,86	1,02
F14. I would like to become a scientist	1,80	1,04

Table 4 shows that the levels of aggrement are rather low in general with no mean over 3 and only three items higher than the midpoint of the scale 2.5.

When interpreting the results of the ROSE questionnaire it is important to bear in mind that the sample involved is nationally representative but the interviews are not. At the top of the list is item F2 which shows that a majority of learners agreed to the statement that science is interesting. When looking closer at the distribution it can be seen that the girls' mean is higher than that of the boys or 2.82 against 2.71 respectively. Although there is a difference here it is not statistically significant at at the according to a T-test.

This is interesting seen in light of the second highest mean 2.56 of the list. This is item F3 'School science is rather easy for me to learn'. This item can be seen as an indicator of expectation of success, an issue that will be addressed later in this paper. The girls' mean from this item was 2.50 while the boys' mean was 2.62 (again not statistically significant according to a t-test). Together with the previous item it can be seen that although girls indicate they are slightly more interested in school science than boys they may be a bit more reluctant to indicate that they find it as easy to learn as boys.

In my interpretation of the interview data I experienced a link between the learner expectations of success (described and measured in Chapter 5.3.1) and attitudes towards science, which is confirmed by the ROSE data. Table 5 shows the correlation between selected items in section F of the ROSE data on school science. In the table it can be seen that item F3 'School science is rather easy for me to learn' has a high positive correlation with a number of other items. These are items like F4 'School science has opened my eyes to new and exciting jobs', F1 'School science is interesting and F5 'I like school science better than most other subjects.

Table 5 Pearson Correlation coefficient matrix of items with strong correlation to item F3 'School science is rather easy for me to learn '

Pearson correlation	F1. School science is a difficult subject	F2. School science is interesting	F4. School science has opened my eyes to new and exciting jobs	F5. I like school science better than most other subjects
F3. School science is rather easy for me to learn	-,676(**)	,498(**)	,483(**)	,528(**)
F1. School science is a difficult subject		-,344(**)	-,326(**)	-,425(**)
F2. School science is interesting			,641(**)	,614(**)
F4. School science has opened my eyes to new and exciting jobs				,637(**)

** Correlation is significant at the 0.01 level (2-tailed).

Item F1 is special as it is the only item in the questionnaire, together with item B12 ‘Having lots of time for my friends (not important/important)’, that showed a strong *positive* correlation (R=0.66) to the Human Development Index (HDI). The strong positive correlation of item F1 and the HDI show that learners from countries with a high development index perceive school science as more difficult than learners in countries with low human development. If this is so this it may affect learner perceptions of the relative cost of engaging in science related activities and learner expectations of success (discussed in Chapter 3.3).

In the interviews learners indicated very strongly that school science was a subject much related to nature and biology and when a relevant profession was to be named, the medical profession was almost always the first to come up. Other professions were not related to school science as directly. Having said that, it can be added that the majority of learners do not agree that school science has increased their appreciation of nature nor opened their eyes for new and exciting jobs (see Table 4). In my opinion this can be used as an argument for saying that school science does not increase an appreciation of nature nor arouse interest in new and exciting jobs. From the views expressed by learners participating in the interviews an appreciation for nature and becoming aware of new and exciting jobs seems to be obtained somewhere else than in school science.

Item F2 ‘School science is interesting’ shows one of the strongest correlations (0.641) to F4 ‘School science has opened my eyes for new and exciting jobs’. What is cause and effect in this relationship is hard to say. This strong relationship could to some extent be used as an argument for the importance of introducing discussions about exciting science related careers to learners in the hope of increasing their interest in the subject.

In the interviews the issues relating to the definition of science literacy came up frequently and often inspired a lively debate about whether science should be obligatory for all. This issue was raised in response to item F6 about whether ‘everybody should learn science at school’ which had a mean of 2.52 in the section and the highest distribution in responses with a standard deviation of 1.22 (see Figure 9). There it is evident that the sample is in fact divided in its views with more of the learners either fully agreeing or fully disagreeing to the statement. What is also interesting is the gender distribution. The girls seem, in my opinion, to take a more nuanced stand with a mean of 2.62 while the boys mean is somewhat lower or 2.40. The difference in the means was statistically significantl according to a T-test. As has been mentioned in previous chapters current school science in the western world finds itself in the midst of a ‘science for all’ emphasis. These results indicate that this policy is not fully accepted by the learners.

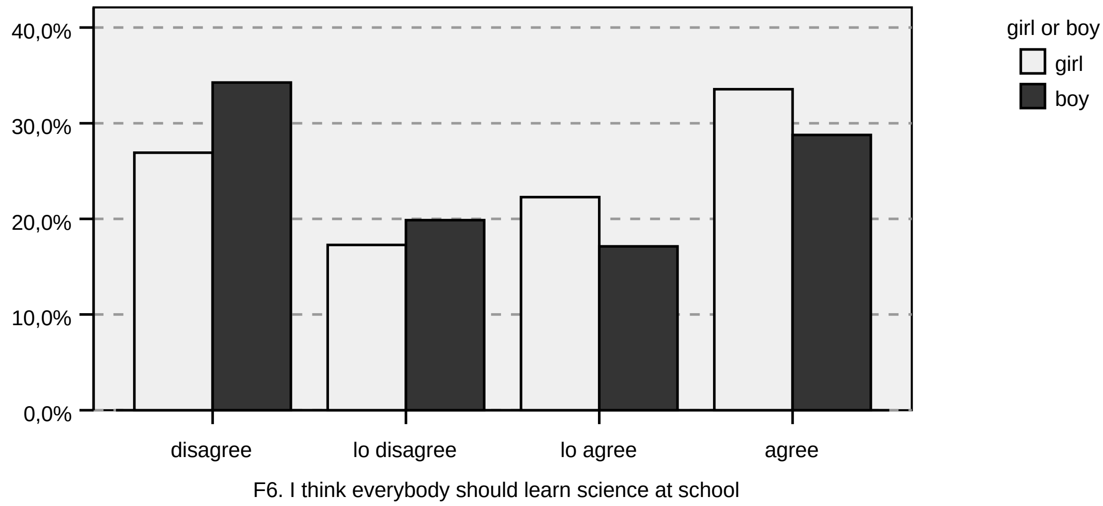

Figure 9 Percentage of boys and girls disagreeing-agreeing that everybody should learn science at school. The learners are split in their opinion.

Although a slight majority of learners indicates that everybody should learn science at school there are not many that would like to have more science than they already have. The response to item F15 ‘I would like to have as much science as possible’ shows that 73% of the learners disagree to the statement to some extent. In the interviews I got the distinct feeling that learners thought that the current amount of school science in the school curricula was appropriate. My interpretation of the situation was therefore that most learners thought school science was important and necessary but few wanted to have more science than they already had.

5.2.2 Perceptions of science and technology

When presenting the plastic board with the word ‘vísindi og tækni’ (science and technology) during the interviews, most learners mentioned sophisticated machines and equipment like computers, television, mobile phones and mp3-players. Ari elaborated the definition of science and technology by saying that these were more a special focus area within ‘school science’ and those things could be introduced within the subject although they were not related to the whole subject. In his mind science and technology are strongly related to invention. Maja and Ósk (who had the lowest self-efficacy of the group, see Chapter 5.3.1) nodded acceptingly.

> *Ari: Science... that is more a sort of distinct part of the field while this (school science) is more the whole field and everything related to it. You can discover different things within the subject although it does not relate to the whole subject.*
>
> *Ósk and Maja: (nodding acceptingly)*

When asked about what kind of work is related to science and technology learners mentioned technicians, programmers and scientists. When asked to elaborate what these professions worked with learners suggested testing and building phones, computers and cameras. This type of response amongst others has led me to the belief that learners feel that science and technology related professions are often related to the invention of useful objects but not necessarily very important objects.

> *Kristján: Well…if you think about professions within the field of science and technology, what professions are related…?*

Kolla: Technician

Íris: Yes, technician, programmer, scientist

Kristján: Þóra

Þóra: The same…

Kristján: Árni

Árni: Just scientist

Kristján: Scientist, some special type or the one we talked about earlier (stereotype scientist).

Árni: Yes... some technical dude or something

Kolla: I see men inventing cameras and that sort of stuff

Kristján: Something related to electricity and computer?

Kolla: Their inventing therefore they have to think a lot

Íris: Yes their doing all sorts of science and they have technical stuff

Kolla: Testing all sorts

Íris: Yeah cameras, telephones and computers

Kolla: Yeah and technical stuff that is used in school science and science

Most learners interviewed showed a keen interest in popular science. Many of them were subscribers to popular science magazines and a number of different science related television programs and soap operas were mentioned during the interviews. Emergency Rescue (ER) was especially mentioned as a popular science related soap-opera. It shows a busy emergency rescue department of a big hospital where doctors and nurses are depicted as heroes. The majority of the learners showed signs of critical reflection when asked about science and the media. Many learners said they perceived science in the media most of the time as something positive. One group referred to positive news about great new inventions like new medicine and robots. Another group had a more skeptical tone towards the media. Members of the group talked about how many TV stations and newspapers have turned to gossip during recent years. When the group was asked how they thought science was shown in the media they said that it depends on the source. From the discussion in the three groups it seemed that the learners were capable of critical reflection in terms of science and the media.

Learners mentioned that they used science and technology every day and they would hardly get through the day if they did not have science and technology. Of things used and most related to science and technology the learners mentioned computers, televisions, iPods, mobile phones and such as running water and toilets. It is interesting to notice that learners only mentioned technology related things whereas scientific thought and reflection was not mentioned as an important part of everyday life.

When asked where knowledge came from there were different answers. Most learners described knowledge as an invention created by people when faced with problems. Ari even went so far as describing it as a continuous process of theories being proven or falsified. It has to be kept in mind that Ari was also the only learner showing a direct intention of becoming a scientist in the future and had been participating in a science program for gifted children.

Tumi: I guess it started when something was to be shared between two persons... they started counting, this is so much, and this is so...

Tinna: and when people started building they needed of course...

Palli: Some problem came up and they needed to find a solution to that problem

Unclear recording: Yes, but someone thought of going into, you know algebra, and that, and I just think...

Unclear: I hate that man

Unclear: Me to

Unclear: Although it is very necessary

Unclear: I hate him anyway

Unclear: It would not be necessary if somebody would not have created it

Unclear: good point

Unclear: yeah, people did not all of a sudden get an idea or something...

Tinna: Well, but on the other hand, you know, if you have something, well, I know this side and this one and you need to know this one, then you need algebra.

Unclear: Yes, that is simple algebra but, you know, we are talking about after that there comes a whole bunch… and you have to fill out a whole page.

Árni: Yes, exactly, one assignment fills a whole page.

Learners in the interview referred to in this section seem to show rather mature epistemological beliefs by connecting the creation of knowledge with people and peoples' abilities to overcome problems using knowledge. But the discussion about the origin of knowledge quickly detoured in this interview into a heated discussion about the relative cost of engaging in algebra. This shows a polarized view towards science, in this case algebra. Science is depicted as necessary but is at the same time a source of feeling of incompetence among learners that otherwise do well in science.

I asked learners to name some Icelandic science and technology related companies. Only a few were able to name a company which used science and technology actively in their production. The most commonly mentioned were companies involved in biogenetics and programming. Not surprisingly the companies mentioned are leading companies that try actively through the media to associate themselves with groundbreaking research. When learners were asked, they described these companies as very important. Some mentioned especially how these companies benefited the nation's economy and were therefore very important.

I followed up this question by asking if learners could see themselves working for those companies in the future. Working for such companies was only acceptable for some of the learners if it involved designing new things. Other things were also mentioned as important such as a good social atmosphere, high salaries and having leadership positions.

Items that shed some light on what learners feel about the science and technology in general are found in section G of the ROSE questionnaire (see Chapter 4.1.1 and appendix). The means of the sixteen items are presented in descending order by means in Table 6. A few of the means are taken for a closer look due to their relevance to the interviews or special statistical anomalies.

Table 6 Means in descending order of agreement with statements about perceptions of science and technology from section G of the ROSE questionnaire.

My opinions about science and technology	Mean (1-4)	Std. Dev.
G1. Science and technology are important for society	3,49	0,77
G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	3,45	0,77
G3. Thanks to science and technology, there will be greater opportunities for future generations	3,43	0,82
G4. Science and technology make our lives healthier, easier and more comfortable	3,17	0,90
G11. A country needs science and technology to become developed	3,08	0,90
G16. Scientific theories develop and change all the time	3,07	0,95
G5. New technologies will make work more interesting	2,99	0,93
G12. Science and technology benefit mainly the developed countries	2,92	1,02
G6. The benefits of science are greater than the harmful effects it could have	2,71	0,94
G7. Science and technology will help to eradicate poverty and famine in the world	2,41	1,00
G10. Science and technology are the cause of the environmental problems	2,30	0,96
G13. Scientists follow the scientific method that always leads them to correct answers	2,27	0,95
G15. Scientists are neutral and objective	2,05	0,91
G9. Science and technology are helping the poor	1,95	0,92
G8. Science and technology can solve nearly all problems	1,86	0,95
G14. We should always trust what scientists have to say	1,67	0,81

Table 6 shows means that are generally quite high considering the four point scale used to obtain them. Nine of the sixteen items are higher that the midpoint of 2.5. This gives higher average agreement rate than in similar questions about perceptions of school science in the previous chapter.

The results from section G in the ROSE questionnaire give information on learner opinions about science and technology. The interviews showed that learners have an established picture of what science and technology is. Science and technology were related to machines and inventions and had little to do with views that biology dominated school science.

Icelandic learners indicated that they felt that science and technology were important (mean 3.49). Of all the other items in this section learners were most in agreement with item G1 ‘Science and technology are important for society.’ Compared to item F6 ‘I think everybody should learn science’ (mean 2.52) from the previous section this mean is higher. There are many ways to interpret these results. I choose to interpret them as indicating that learners do not feel that they experience what they consider to be real science in schools. Instead they cling to an image of science adopted from their socializers. Science is seen as very important for society but not necessarily for everybody to learn. The science learnt and the science that is important are not one and the same thing in the mind of the Icelandic learner. The response to these items could help to lay to rest the myth that the only thing that Icelandic teachers have to do to increase interest in the school science is to help the learners to realize the importance of science for society. This importance seems well established as can be seen in Figure 10.

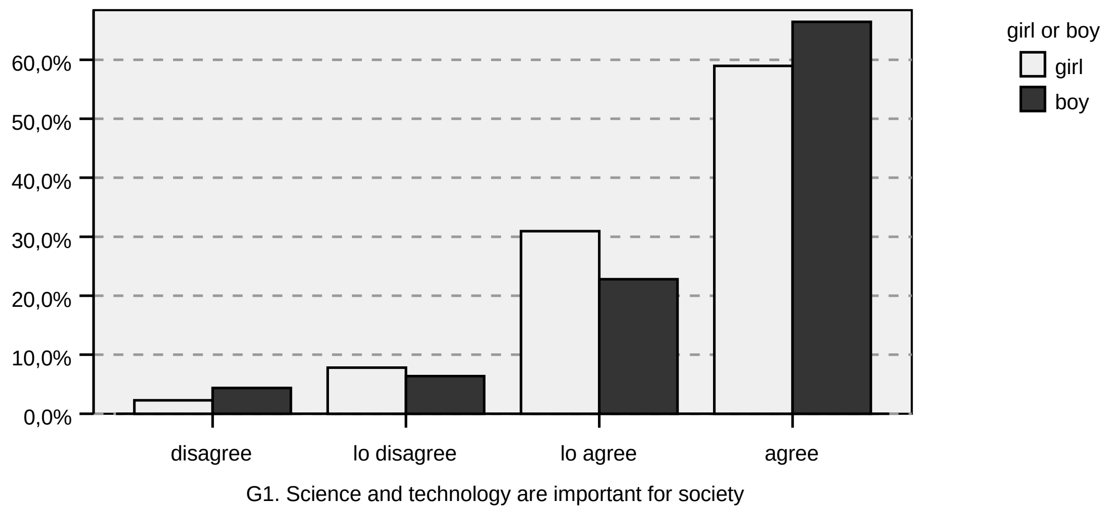

Figure 10 Percentage of boys and girls disagreeing-agreeing that science and technology are important to society. Learners strongly agree with the statement.

As mentioned in earlier chapters the developers of the ROSE questionnaire felt that learners should develop an attitude of critical reflection towards science and technology issues. This is also clearly stated in the Icelandic science curricula from 1999 and in the draft revised version of 2005 (Menntamálaráðuneytið, 2005). It is therefore enjoyable to see that Icelandic learners do not agree to statements that indicate unconditional trust towards science and technology (means below 2.5 in Table 6).

It is important to realize however that many of the items in Table 6 indicate that beliefs in the value of science and technology are high. An example of such items are for example items like G2 ‘Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.’, G3 ‘Thanks to science and technology, there will be greater opportunities for future generations’ and G5 ‘New technologies will make work more interesting’. So at the same time as unconditional trust towards science and technology is rejected the learners believe in the general value of science and technology.

It is worthwhile mentioning that among the items on the disagreement side of the scale there are two items specifically directed at how science and technology are perceived in relation to solving problems related to poverty and famine. G7 ‘Science and technology will help to eradicate poverty and famine in the world’ and G9 ‘Science and technology are helping the poor’. These items are both on the disagreement side in the table of means although item G7 which refers to the future is much closer to the middle then G9. In my opinion this indicates a critical reflection on behalf of the learners on the current distribution of wealth and knowledge.

The gender difference in section G was generally small with one exception. The item with the highest gender difference 0.5 (measured as the difference in gender means) was item G8 ‘Science and technology can solve nearly all problems’. A vast majority of girls or 87% of all girls disagreed to some extent to this statement while only 65% of the boys disagreed (see Figure 11).

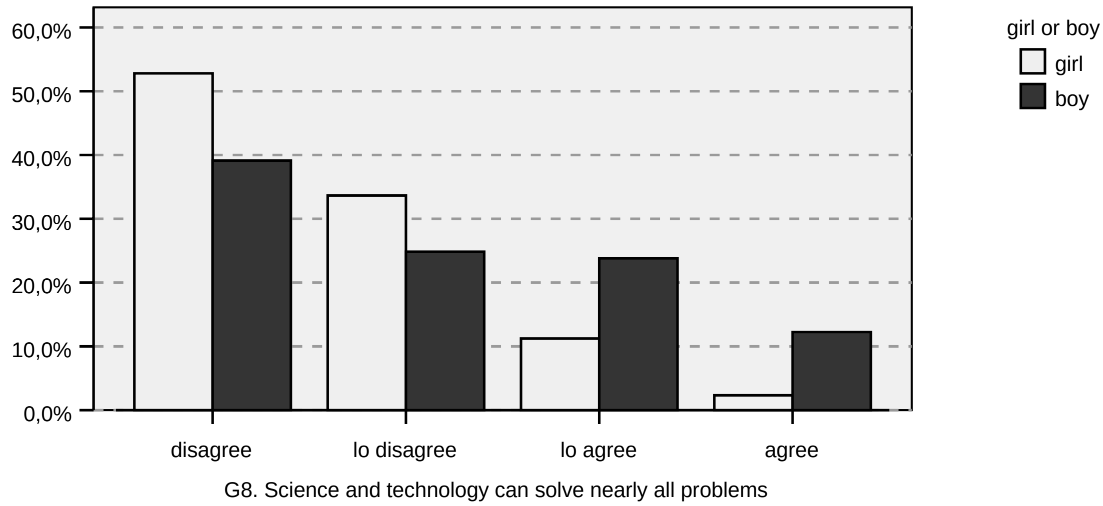

Figure 11 Percentage of boys and girls disagreeing-agreeing that science and technology can solve all problems. Learners disagree to the given statement.

To try to understand the results I calculated the Pearson correlation coefficient for the F and G items and looked for the items which correlated the most with item G8 (see Table 7).

Table 7 Pearson correlation coefficient matrix of items that correlated strongly with item G8 'Science and technology can solve nearly all problems'. Item G8 correlates to three other items that all have to do with unconditional trust to science and technology.

	G7. Science and technology will help to eradicate poverty and famine in the world	G9. Science and technology are helping the poor	G14. We should always trust what scientists have to say
G8. Science and technology can solve nearly all problems	,529(**)	,502(**)	,489(**)
G7. Science and technology will help to eradicate poverty and famine in the world		,506(**)	,333(**)
G9. Science and technology are helping the poor			,284(**)

** Correlation is significant at the 0.01 level (2-tailed).

From the results in Table 7 I assume that learners who agree that science and technology can solve nearly all problems in the world often also seem to agree with other statements related to unconditional trust towards science and technology.

5.2.3 Perceptions of scientists

During the interviews learners often said scientists when talking about science and science when talking about scientists. This indicates in my opinion that these two factors could be highly related. The items in the ROSE questionnaire involving scientists did not for example have a section of its own. Instead the items were divided between section F 'My science classroom' and G 'My opinion about science and technology'. In this chapter I will look at the instances when scientists came up in the discussion during the interviews and select items from section F and G involving scientists for further analysis.

During the interviews the definition of the term scientist did not seem to encourage the willingness to engage in science related issues. The term seemed to have an unattractive meaning in the minds of most learners interviewed. When learners were asked if they knew a scientist personally they did not think so at first. Soon the 'smart one', Ari, realized what I was aiming at and told us his sister was a doctor. Then one of the girls, Ósk, asked the golden question: 'Are doctors' scientists?' And straight afterwards Jón also put a question mark as to whether engineers were scientists? This repeatedly happened during the interviews, and although learners could well accept that doctors could be called scientists it was not considered to be the appropriate thing to call a doctor.

Kristján: Do you know any scientists personally?

Maja: Personally? How so?

Kristján: Is there anyone in your near family or your next door neighbor?

Maja: No... (hesitating)

Kristján: Any of you?

Ari: My sister is a doctor

Maja: Is that science?

Kristján: That is a good question?

Jón: An engineer ehhh? (Jón did not perceive engineers as scientists).

Kristján: Are they scientists engineers, doctors?

Ósk: I know at least two then!

When asked to define what image of a scientist they had the description the learners gave was quite clear. The scientist was male, in a white coat, middle-aged, strange looking, and all knowing, distracted and a bit geeky. This result is in agreement with the findings of McDuffie (2001) reviewed in Chapter 2.3 which reveal that the teacher's stereotypes are the same as their learners on most significant characteristics.

Kristján: Anything else you can say that defines scientists in appearance and behavior?

Yes, ok, Kolla is drawing a man with glasses and strange and curly hair.

Kolla: Ok (finished drawing the picture)

Íris: A bit, you know, geeky

Kristján: But how do they behave are they social?

Íris: The calm type, not very social

Kolla: Yes, I think they are social, I just think their a bit different.

Árni: Within a group of nerds

Íris: Yes within a group of nerds

The majority of the learners in the interviews wanted to engage in the medical profession after their studies. Not surprisingly the learners had a hard time associating the geeky image of the scientist with the image they had of doctors. When asked what was fascinating about the medical profession the issue of helping others frequently came up. It seemed as if the medical profession was seen as a meaningful line of work that was socially acceptable to express a willingness to engage in.

In a follow-up question I asked one group to explain to me the difference in the help we get from doctors and from scientists. The group said that we receive direct help from the doctors but indirect help from the scientist. In the same group it was pointed out that scientists worked at making things more related to increasing comfort and an easier life but not always necessary. The importance of public recognition seemed to be of great importance and fits well with the definition of attainment value discussed in the previous chapters.

Kristján: What is the difference in that between doctors and scientists?

Ari: Direct help from the doctors and indirect help from the science

> *Kristján: Indirect help from the scientists?*
>
> *Ósk: That is more a sort of comfort*
>
> *Ari: That is maybe something that you do not necessarily need*
>
> *Maja: You might not know who made the technology but you know who the doctor was*

There were five items that were specifically aimed at learner perceptions of scientists in the ROSE questionnaire, two in section F and three in section G. I have chosen to look at them in relation to each other in a separate table of means (see Table 8).

Table 8 Means in descending order of agreement with statements about scientists from section F and G of the ROSE questionnaire.

Perception of scientists	**Mean (1-4)**	**Std. Dev.**
G13. Scientists follow the scientific method that always leads them to correct answers	2,27	0,95
F16. I would like to get a job in technology	2,16	1,10
G15. Scientists are neutral and objective	2,05	0,91
F14. I would like to become a scientist	1,80	1,04
G14. We should always trust what scientists have to say	1,67	0,81

All of the means were lower than the 4 point scale midpoint of 2.5 indicating general disagreement with the statements. The response to the three items (G13, G15 and G14) that directly relates to learner perceptions of scientists shows that Icelandic learners do not have unconditional trust towards scientists (see Table 8). As can be seen in the chapter about learner perceptions of science and technology the majority of learners in Iceland realizes the importance of science and technology for society. Furthermore, they have high beliefs towards science and technology. But that does not mean that learners trust science and technology unconditionally or in this case scientists. Of all the 58 ROSE items in sections B F and G of the ROSE questionnaire item G14 ‘We should always trust what scientists have to say’ had the lowest mean of all or 1.67; the distribution can be seen in more detail in Figure 12.

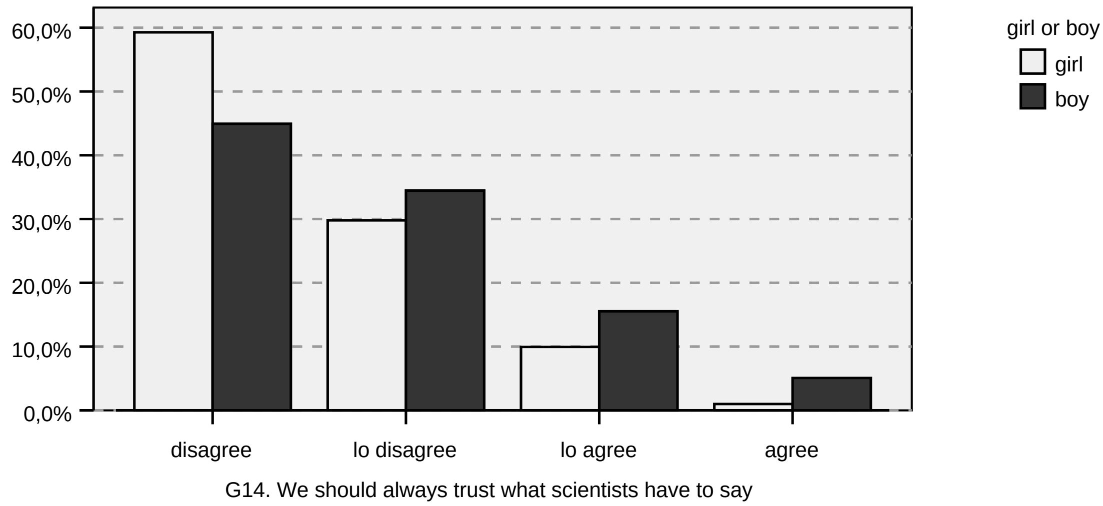

Figure 12 Percentage of boys and girls disagreeing-agreeing to the given item. Learners disagree that they should always trust what scientists have to say.

I interpret this as positive as it adds on to the general wish that learners should be able to critically reflect on what scientists have to say. Previously I mentioned that the interviews indicated that learner perceptions of science and technology and scientists was related in some way. When comparing Figure 12 with Figure 11 on page 58 it can be seen that learners disagree to a greater extent with item G14 (involving trusting scientists) than G8 (involving trusting science). After analyzing the interviews I suspect that this difference is caused by the more narrow definition that the term scientist has in the minds of learners. To put it in simple terms, the scientist is more related to an uninspiring technological dimension of science while the definition of science and technology seems fuzzier and can be related to a wider field of interest.

The second lowest mean of all the items under consideration in this research was found in item F14 ‘I would like to become a scientist’ with a mean of 1.80. The distribution of the answers can be seen in Figure 13. The trend was similar between the boys and girls although more girls tended to disagree more strongly.

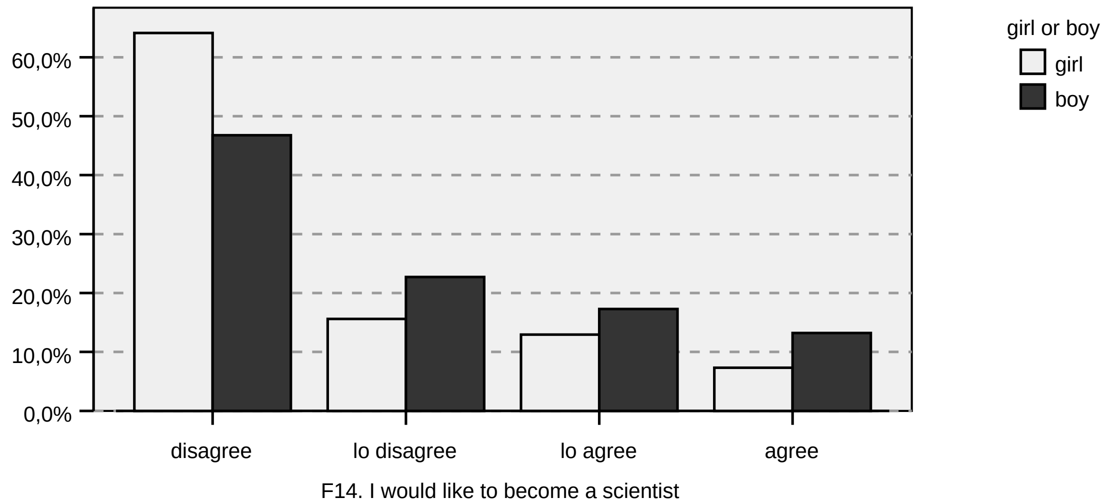

Figure 13 Percentage of boys and girls disagreeing-agreeing the given item. Learners disagreed that they would like to become scientists.

Item F14 ‘I would like to become a scientist’ correlated to a number of items but the strongest positive correlation was to F15 ‘I would like to have as much science as possible at school’ with a Pearson correlation coefficient of 0.6. Correlations like these are always hard to interpret as is explained in Chapter 4.3.1. If I assume that learners generally believe that those who engage actively in science are going to become scientists this could have a negative effect for learner willingness to engage in science related issues. I choose to interpret these results as an argument for the need for parents, peers and teachers to show caution in their interaction with learners that choose to engage in science. The lack of such caution can in my opinion lead to some learners being labeled as geeks for engaging in science.

5.2.4 Perceptions of scientific careers

In the following text I will try to shed some light on learner perceptions of scientific careers. This will be done by analysis of the data from the group interviews and data from section B of the ROSE questionnaire on careers in science. At the same time as the main focus will be on scientific careers, general questions about the perceived importance regarding future occupations will be addressed.

During the interviews the learners repeatedly mentioned the medical profession as an attractive line of work. I asked one of the groups to consider other science related professions and compare them to the medical profession and then tell me why the medical profession was so fascinating. The learners said that they had heard that being a doctor would be very rewarding and fun. The fact that doctors help people and are well paid came as an additional argument. The enjoyment of work was repeatedly mentioned as more important than very high salaries.

Kristján: What about other fields within school science - aren't they as fascinating? What is more fascinating about medical studies?

Ýr: Then you can help people

Ósk: Very rewarding

Ýr: I have heard a lot about how fun it is

Kristján: Ýr, you mentioned earlier that helping people is important, but what about money?

Ósk: Also

Jón: Yes

Everybody: (smile a bit embarrassed)

Kristján: Doesn't that matter?

Everybody: Yes

Ósk: It matters a lot

Ýr: But it is better to be in a fun job with less money then being in a very boring job with lots of money.

Jón: That's right

Some of the learners revealed a somewhat naive perception of their preferred future occupation. One of the girls Íris for example wanted to become a midwife. When asked why she wanted to become a midwife she answered that she liked to help others and be around kids. As the midwife profession mainly involves education and pre- and post-natal support it is unlikely that Íris would get a chance to be around kids much other than newborn infants. I take this as an example of how the image of the preferred choice of future occupation often seemed distorted or unclear to learners during the interviews. This discussion frequently led learners to independently wish for more school visits and more insight into the unknown world of adult life work.

Similarly Jón who wanted to become an engineer was not able to tell what engineers do. When the group started discussing what engineers do they specifically regarded it as a male-dominated job which often included standing outside in a yellow vest, wearing a safety helmet and inspecting a construction site. This was not a particularly attractive image to the girls in the group. The only argument Jón came up with for his wish to engage in engineering was that his father was an engineer and therefore he wanted to become one as well. In Jón's case one could say that the effect of an important socializer like his father has played a dominant role in his perception of the profession.

When asked about where learners received information about possible career opportunities in science and technology the most frequent answer was television, after that the internet and then parents. The TV program Emergency Rescue (ER), mentioned earlier, was specifically mentioned as depicting the medical profession as interesting. One of the groups mentioned that although the drama in the TV series was clearly blown out of proportion this was the closest that they could get to the real thing.

The interesting bit was that none of the groups mentioned the school career counselor when asked about their sources of information, although all the schools had a career counselor on their staff. When specifically asked about career counseling some learners mentioned that the counseling was mainly aimed at introducing and recommending different trajectories in the upper secondary schools.

> *Kristján: If you could consider working within this field (science and technology) which many of you are - where do you get information about it? Þórarinn, you said, you just don't get information.*
>
> *Þórunn: From TV. That is the only thing that comes into mind.*
>
> *Kristján: From TV. Which programs?*
>
> *Þórunn: Well, you know its nothing like, you know, for example medical studies, I wouldn't know anything about what doctors do, unless, you know, because I'm not so often in the hospital, but you know, like ER and that sort of stuff…*
>
> *Unclear: That's so dramatized*
>
> *Þórunn: Yes, I know, you know, this is like the closest thing you get in getting some real information about it.*
>
> *Tinna: But none the less, if you want to look for information you can always go on the internet and find something there if you…*
>
> *Tumi: On the net, ask someone, call some employers...*
>
> *Unclear: Probably mostly the internet*
>
> *Tinna: Also if you know someone then you can ask him*
>
> *Palli: We get very little from the school, I can tell you that*
>
> *Kristján: Isn't there any career counseling?*
>
> *Unclear: Yes*
>
> *Unclear: Yes, but it is mainly related to upper secondary school studies*

All of the groups mentioned that they were yet to experience the yearly 10th grade work visit days. When asked in more detail they said that they had to arrange the work visits by themselves and they would get a few days leave from school to visit a work place of their own choice. Tumi informed us that he had arranged a helicopter ride with the Icelandic coast guard as a part of his work visit. Others, like Tinna, indicated that she was not going to arrange anything and would just grab the chance to get a couple of days vacation from school. When learners were asked they said they wanted more work visits arranged by the school authorities and if possible already in 9th grade as the studies for the national exams at the end of 10th grade took up most of the time they had during the 10th grade school year.

What learners find important in regards to their future job was assessed in Section B of the ROSE questionnaire. Section B is different from section F and G of the ROSE questionnaire. The learners were asked to indicate the level of importance attached to the items, instead of agreement, and a scale of 4 points was used. The list of means in descending order can be found in Table 9.

Table 9 Means in descending order of importance of statements about future job from section B of the ROSE questionnaire.

My future job (not important/important)	Mean (1-4)	Std. Dev.
B9. Using my talents and abilities	3,58	0,74
B16. Working with something that fits my attitudes and values	3,55	0,73
B13. Making my own decisions	3,55	0,69
B17. Having lots of time for my family	3,53	0,75
B15. Working with something I find important and meaningful	3,52	0,75
B25. Developing or improving my knowledge and abilities	3,49	0,72
B12. Having lots of time for my friends	3,45	0,74
B20. Earning lots of money	3,41	0,74
B23. Having lots of time for my interests, hobbies and activities	3,40	0,75
B19. Working at a place where something new and exciting happens frequently	3,16	0,83
B11. Coming up with new ideas	2,97	1,00
B1. Working with people rather than things	2,93	1,05
B2. Helping other people	2,91	1,00
B14. Working independently of other people	2,89	0,94
B26. Working as part of a team with many people around me	2,89	0,87
B10. Making, designing or inventing something	2,81	1,06
B18. Working with something that involves a lot of traveling	2,61	0,93
B24. Becoming 'the boss' at my job	2,52	1,02
B8. Working artistically and creatively in art	2,37	1,15
B21. Controlling other people	2,28	1,04
B22. Becoming famous	2,25	1,08
B7. Working with machines or tools	2,21	1,14
B5. Working with something easy and simple	2,10	0,99
B3. Working with animals	2,07	1,06
B6. Building or repairing objects using my hands	2,06	1,08
B4. Working in the area of environmental protection	1,87	0,95

The outcome of this section confirms many of the issues that came up during the interviews. First of all it can be seen in Table 9 that the top seven means all contain the word ‘my’ or ‘I.’ These statements are all connected to the importance of self-realization in the future job. These means are all very high (3.45-3.58) together with low standard deviation indicating a general agreement among the learners. This fits well with the general notion I got from the interviews that learners perceived their future job as an important part of themselves and of having an important and meaningful life.

One of these seven items stands out because of its strong positive correlation to the Human Development Index (HDI). This can be seen in item number B12 ‘Having lots of time for my friends (not important/important)’. In this item the national means of countries with high human development are systematically higher than those of countries with low human development with a Pearson correlation coefficient of 0.863. This distribution can be seen in more detail in Figure 14.

B12 Having lots of time for my friends (not important/important)

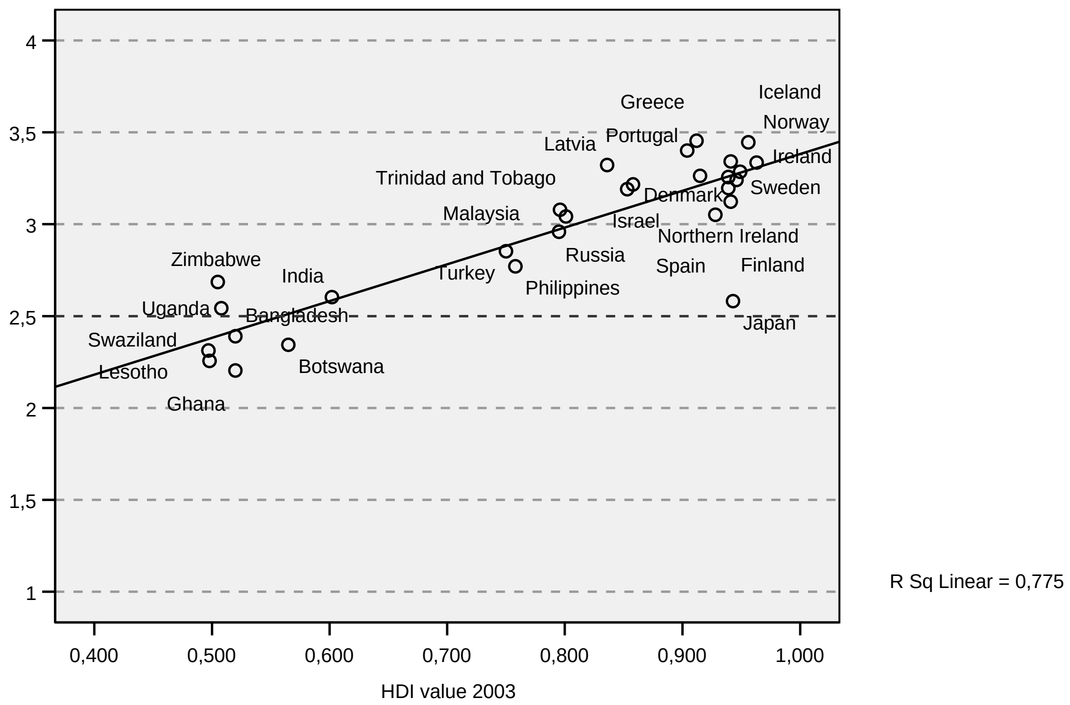

Figure 14 Correlation between the national mean of item B12 (Y-axis) and the Human Development Index (X-axis). Learners from countries with high human development indices consider having lots of time for their friends important in their future job.

In my opinion this the strong positive correlation of item B12 and the HDI confirms what seems to be the important role friends seem to have in countries with a high human development index. It can be used as an argument for the effect friends as socializers seem to have on learner perceptions and eventually the learners’ willingness to engage in science related issues in countries with high human development. I calculated the correlation coefficient for the national means of item B12 ‘Having lots of time for my friends (will be important to me)’ and F14 ‘I would like to become a scientist.’ The calculation showed a strong negative correlation with Pearson correlation coefficient of -0.835. This is shown in Figure 15.

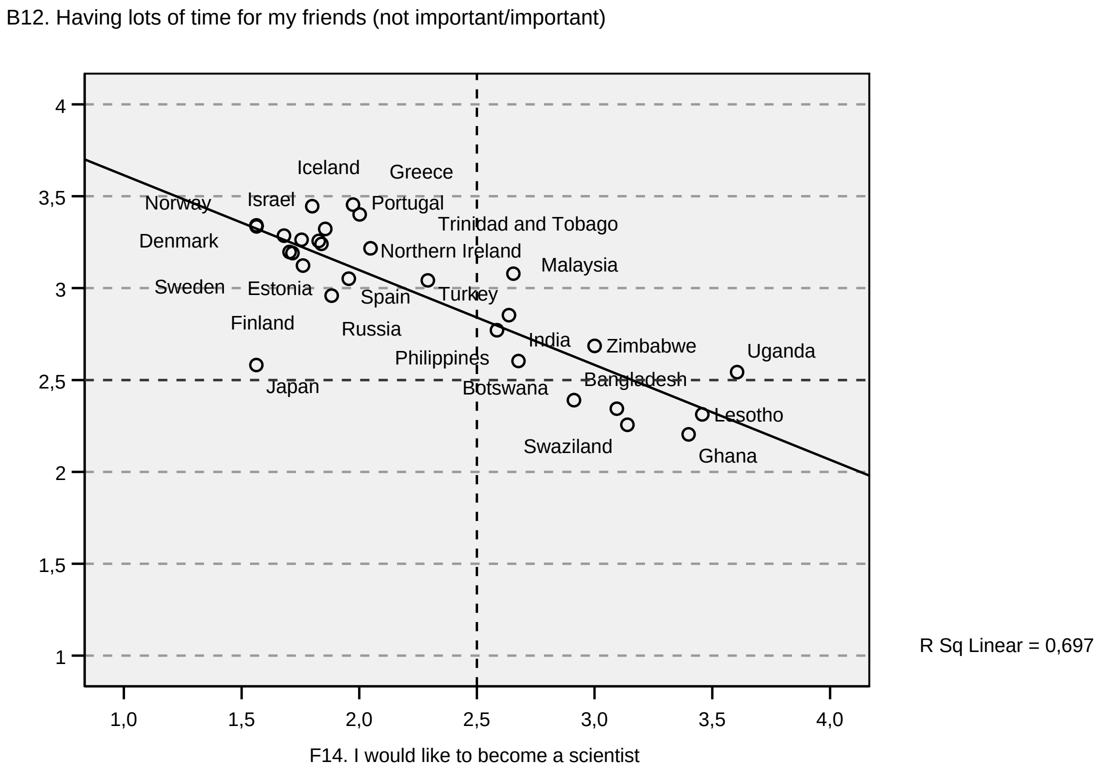

Figure 15 Correlation between the national mean of the importance of friends in their future job (Y-axis) and the national mean of whether the learner would like to become a scientist (X-axis). Learners who find it important in their future jobs to have lots of time for their friends are also learners who do not want to become scientists.

The correlation between the two items in Figure 15 is not necessarily the case if the correlation is calculated nationally which indicates the importance of the social environment in this comparison. As previously mentioned caution is required when interpreting correlations like these. I find it tempting to use these results as a further argument to the importance of self-realization in future jobs of learners from countries with high human development indices. Science related careers may project the image that learners will not have lots of time for their friends, if any. The factor of peer is clearly a complex and important one therefore these result are in agreement with the findings of Wang and Staver (2001), reviewed in chapter 2.1, where the researchers called for more empirical studies on relationships of peers in the context of school science.

Generally the different genders seemed quite in unison in their opinions of what is important and what not for their future jobs in regards to self-realization. The gender difference increases however when the learners were asked to evaluate the importance of traditional male or female job characteristics. This reflects for example in item B7 ‘Working with machines or tools’ which had the highest difference in means (1.00) in favor of the boys. The response can be seen in more detail in Figure 16.

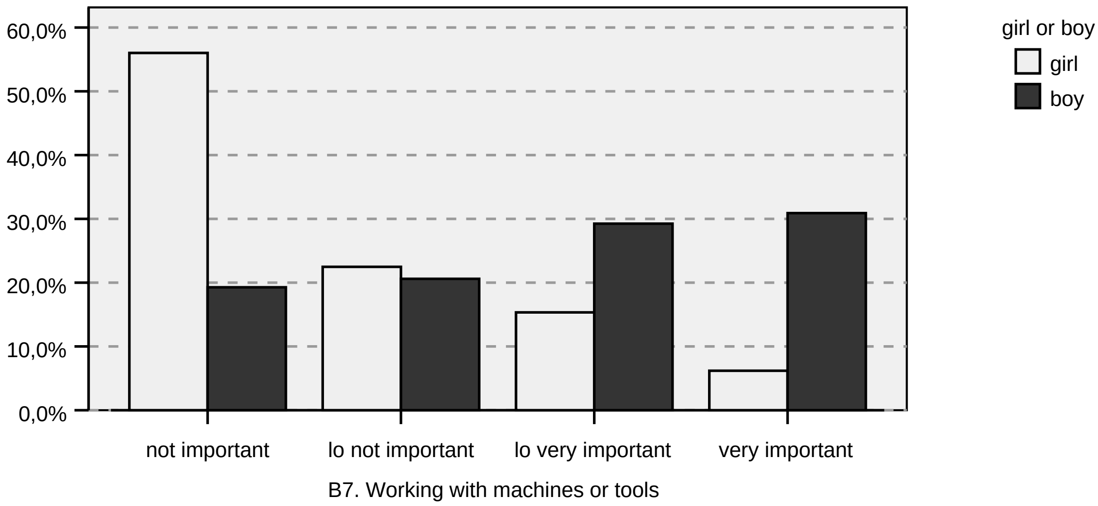

Figure 16 Percentage of boys and girls indicating the importance of working with tools for their future jobs. Girls did not find working with machine or tools important for their future jobs.

A similar difference (0.76) was found in item B6 'Building or repairing objects using my hands (not important/important)'. Other traditional differences were also found in favor of girls. The highest difference (0.76) in their favor was in item B2 'Helping other people (not important/important)' and the second highest (0.69) in item B8 'Working artistically and creatively in art (not important/important)' and the third highest (0.58) in item B1 'Working with people rather than things (not important/important)'.

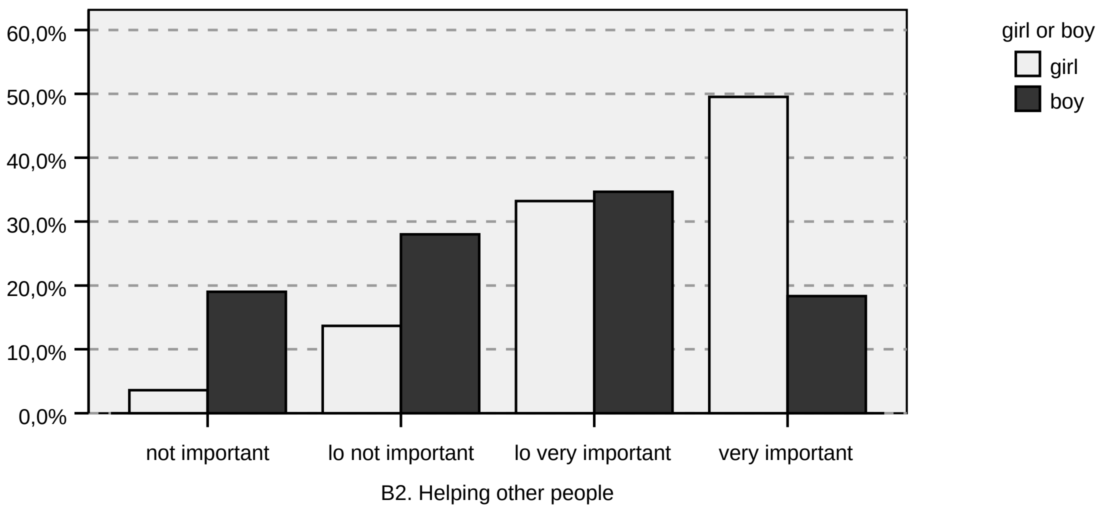

Figure 17 Percentage of boys and girls indicating the importance of helping other people for their future jobs. Girls find helping other people very important for their future jobs.

Maybe the reason for the high interest in medical studies observed in the interviews can be related to this emphasis on people and how they can be helped. As can be seen in the distribution of the responses in Figure 17 the majority of the boys also find this important to some extent. The gender difference in both item B7 and B2 as can be seen in the two previous pictures mainly occurs due to the fact that the largest group of girls ticked in the outermost boxes of the four point scale. The boys on the other hand show a more varied response.

5.3 Willingness to engage in science related issues

The results and discussion presented in this section are based on limited data and are not meant to give a comprehensive picture of the Icelandic learners willingness to engage in science related issues. The purpose of this section is to highlight the results and open the discussion about the role learner perceptions play in the adapted model of achievement related choices. This way I seek to reveal the strengths and limitations of studying learner perceptions towards science related issues in an Icelandic context.

5.3.1 Expectation of success

Expectation of success is central when estimating a child's achievement related choices and performance, as described in Chapter 3.3.1. I believe that learner expectation of success in science related issues is as important as the subjective task value in contributing to the willingness to engage in those issues as described in the adapted model (see Figure 3). To get some sort of idea of the importance of the learner expectations of success I asked the learners to fill out an electronic questionnaire after each group interview. This was done by using adapted and simple measures of self-efficacy at subject-specific measurement level.

Subject-specific self-efficacy, or self-efficacy as I will now refer to it, was measured by asking the learners to indicate on a five point scale how confident they were in receiving a given grade on their upcoming science exam. This was done by writing 'How confident are you that you can…' and presenting seven statements which included different grade levels. These items are described in more detail in Chapter 4.1.6. The outcome is presented as means in descending order in Table 10. It has to be kept in mind that when I speak of *learners* in this section I am always referring to the specific learners that participated in the group interviews.

Table 10 The subject-specific self-efficacy of the learners that participated in the group interviews. The girls tended to have lower means then the boys.

Boy	Subject-specific self-efficacy (1-5)	Girl
	4,71	Þórunn
Jón	4,57	
Tumi	4,57	
	4,57	Ýr
Ari	4,43	
Böðvar	4,43	
Karl	4,43	
Palli	4,43	
	4,14	Kolla
	4,00	Maja
	3,86	Þóra
	3,71	Ósk
Árni	3,57	
	3,57	Tinna
Stefán	3,43	
Þórarinn	3,14	
	2,43	Íris

Table 10 reveals that among the nine highest means there are two girls and seven boys and among the bottom nine there are six girls and three boys. To realize the difference in learner response we can compare what Íris (who had the lowest mean) and Ari (who had one of the highest means) indicated in their response (see Table 11). In Iceland grades are traditionally given on a ten point scale where five is the minimum grade to pass and ten is the top grade.

Table 11 Íris´s and Ari´s response to the subject-specific self-efficacy items.

Subject-specific self-efficacy item	Ari	Íris
Pass science at the end of this term?	Very confident (5)	Lo Very confident (4)
Pass science with a grade better than 5?	Very confident (5)	Lo Very confident (4)
Pass science with a grade better than 6?	Very confident (5)	Neutral (3)
Pass science with a grade better than 7?	Very confident (5)	Lo Not confident (2)
Pass science with a grade better than 8?	Very confident (5)	Lo Not confident (2)
Pass science with a grade better than 9?	Lo Very confident (4)	Not confident (1)
Get grade 10 in science?	Lo Not confident (2)	Not confident (1)

Íris used four out of five response categories available. The only category she did not use was the category ‘Very confident’. Ari on the other hand used only three categories. He was ‘Very confident’ that he would get a higher grade than eight in science at the end of the term and ‘Lo Very confident’ that he would get nine and ‘Lo not confident’ that he would get ten. All learners in the interviews were considered, by their teachers, to be relatively good science learners. It seems like the majority of the boys were more willing to express their confidence in science than the girls. Could the difference in the gender expectation of success relate in some way to their perception of science related issues? In an attempt to shed some light on this question I went back to the interview data and compared the transcripts from learners with low self-efficacy with the transcripts from learners with high self-efficacy. An interesting theme emerged in the two groups as the less confident learners indicated what I call a negative disposition towards many of the science related issues under consideration. This is a theme which would be useful to consider more carefully.

This was especially evident with Íris who showed the least confidence in getting a good grade in science at the end of the term. Íris said that she was not so interested in school science but she wanted to become a midwife and therefore she was obliged to engage in the subject. Íris´s perception of scientists was in my opinion negative as well. As can be seen in Chapter 5.2.3 Íris repeatedly considered scientists to be nerds and unsocial. In our discussion about the learner perceptions of school science vs. science and technology Íris bluntly denied that school science and technology were related issues. In our epistemological discussion Íris indicated a view on the origin and scope of knowledge that in my opinion could easily discourage learners to engage in science related issues as it portrays scientific knowledge as static and therefore unexciting.

> *Kristján: Ok, right, what do you... here is a tough one, what is the origin of knowledge? You know, what is knowledge?*
>
> *Kolla: You learn*
>
> *Kristján: Yes, you learn, but when did it emerge, like for instance mathematics?*
>
> *Karl: It has always existed*
>
> *Kristján: It has always existed? Was there someone who invented mathematics?*
>
> *Kolla: Yes*
>
> *Árni: The Romans*
>
> *Karl: The people who invented mathematics - they were defining it*
>
> *Íris: I think that mathematics has always existed but nobody knew it exactly. But you know... like the Romans or something came up with it then*
>
> *Kolla: They managed to write the rules*
>
> *Kristján: So it has always existed, but it was people that….*
>
> *Íris: ... put rules on mathematics*

At this stage I feel obliged to point out that this view was also shared by Karl and Kolla who both had relatively high self-efficacy values. Overall I was not surprised to see that Íris had the lowest self-efficacy as her perceptions of the science related issues in most cases did not coincide with others in the group.

Ari is on the other hand an example of a learner with high self-efficacy (see Table 10). Like the majority of the boys in the interviews he expressed high confidence in getting good grades at the end of the term. When looking at his transcript one can see that it is filled with dreams about a future career within science. Ari for example has decided that he wants to engage in science studies at a higher education level. Ari finds science programs and magazines fun and exciting, while two girls, Maja and Ósk, in his groups were reluctant to agree to that.

Kristján: How do you like things like Discovery Channel, Popular Science and such?

Ari: Very interesting and fun

Jón: Fun

Maja and Ósk shake their heads

Ósk: No… I don't follow it much

Kristján: Maja and Ósk not so interested?

Ósk: I prefer Eurosport or something

The group Ari was in was especially keen on seeking a career within science and especially the medical profession in the upcoming future. When asked what they saw as mostly attractive or unattractive in seeking such a career Ari immediately said that science was *'of course very hard to study'*. Then he expressed contradictory views in the same sentence as he said that the content driven science curricula was the thing that was the most unattractive but added to the same sentence that he liked such studies very much. In this case I think Ari was expressing that science is viewed as unattractive to many in his class because of how time-consuming it is to get good grades. He at the same time was and had been a part of a reinforcing process where getting relatively good grades, in a subject that is publicly accepted to be tough, had built up his self-efficacy leading to the development of positive and self-aiding skills (see formal definition of self-efficacy in Chapter 3.4).

Kristján: The four of you that are thinking about a future career in science and technology. Can you wonder why?

Ýr: I'm thinking about science as well

Kristján: Yes you are thinking about science as well. But, all of you, what is unattractive about a future career in science and technology? Or what is attractive?

Ari: Well, it is of course a hard study

All: (agree)

Ari: It is very content driven. That is maybe what is the most unattractive. But I myself like that kind of studies very much

Kristján: Hard work?

Jón: Read a lot

All: (agree)

In the electronic questionnaire there were a few open-ended items made to gather background information about the learners. In one of these questions the learners were asked if their friends were interested in school science related things. Only five learners gave enough positive information for me to conclude that their friends were interested in these issues. Interestingly enough these five learners are among the six learners with the highest self-efficacy of all seventeen learners interviewed. This together with the discussion about the importance of friends in Chapter 5.2.4 makes this an interesting issue. This might be used as an argument for further research on the social element of school science. Friends as socializers seem to affect the learner perceptions and confidence in science and finally his or her willingness to engage in the subject. This result is in agreement with the findings of Stake and Nickens (2005) reviewed in Chapter 2.3 where having peers with whom to share science interests was considered to enhance both girls and boys imagined future personal life as scientists.

5.3.2 Subjective Task Value

As described in Chapter 3.3.2 the creators of the general-expectancy value model of achievement choices assume that *STV is a quality of the task that contributes to the increasing or decreasing probability that an individual will select it.* Eccles (2005) defines this quality of tasks in terms of four components:

1. *Attainment* value or the value an activity has because engaging in it is consistent with one's self-image,
2. *Intrinsic or interest* value, expected enjoyment of engaging in the task,
3. The *utility* value of the task for facilitating one's long-range goals or helping the individual obtain immediate or long range external rewards, and
4. The *cost* of engaging in the activity.

I will give some examples of each of these components from my interview analysis and discuss some themes that came up during the analysis.

Attainment value

Attainment value is described as the value an activity has because engaging in it is consistent with one's self-image. As previously discussed in Chapter 5.2.4 learners indicated that the most important thing about their future job was its consistency with their self image. In that sense it is possible to say that the attainment value of the future job was an important part in their choice. During the analysis of the interviews the same trend was evident regarding the engagement in science related issues. Most references were made to the attainment value of the four components under consideration. In the following are some examples with reference to Eccles (2005) description of the attainment value component.

During the interviews I asked some of the learners that indicated that they did not seek a career in science and technology why a career in science and technology seemed unattractive to them. The answers I got inspired the title of my thesis 'I just don't think it's me'. I interpret this simple answer as an indicator of one of the main reasons some Icelandic learners choose not to engage in science related issues. I think that what the learner is really trying to say is: *'I just don't think science and technology is consistent with my self-image'*.

> *Kristján: But for example, you Maja, you were not thinking about a career related to science or what?*
>
> *Maja: No*
>
> *Kristján: Why not?*
>
> *Maja: ... I don't know, I just don't think it's me, somehow, I don't know*

At one place in the description of the attainment value the motivation for engaging in a task is said to be influenced by the extent to which the task provides the opportunities to fulfill the learners' basic needs, amongst other things:

1. the need to feel that what one does matters in a fundamental and important way to one's social group, and
2. the need to feel respected and valued by one's social group.

The need to feel that what one does matters and is fundamental and important to one's social group is seen in learner emphasis on the medical profession as an attractive career and the importance of helping others. This is also evident in the discussion about scientists where scientists are not considered to be working with fundamentally important things and only help people indirectly. This result is in agreement with the findings of Kniveton (2004) reviewed in Chapter 2.1. The need to feel respected and valued is also clear when Maja points out that people always know which doctor treated them but almost never who invented this machine or that technology.

> *Kristján: Do engineers help people? We were talking about that helping people was important in medical studies*
>
> *Jón: Yes but not in the same way as medical studies*
>
> *Kristján: Not in the same way?*
>
> *Jón: No exactly*
>
> *Kristján: What is the basic difference, in the element of helping others, how do engineers help people and how do for example scientists help people?*
>
> *Ari: Better their lives with machines and technology*
>
> *Kristján: What is the difference in that between doctors and scientists?*
>
> *Ari: Direct help from the doctors and indirect help from the science*
>
> *Kristján: Indirect help from the scientists?*
>
> *Ósk: That is more a sort of comfort*
>
> *Ari: That is maybe something that you do not necessarily need*
>
> *Maja: You might not know who made the technology but you know who the doctor was*

The observant reader might notice that the last part of this quote is also in Chapter 5.2.3 about learner perceptions of scientists. This reinforces how the attainment value is in this case is reflected in learner perceptions of scientists in the adapted model of achievement choices (see Figure 3).

At one place in the description of attainment value in Chapter 3.3.2 I refer images that we develop as we grow up, images that tell us who we are and what we would like to be. One of these is said to be our schema regarding proper roles of people 'like us' (e.g. boys vs. girls) as well as our more general social scripts regarding proper behavior in a variety of situations. The proper role of people frequently arose during the interviews. Some of the girls indicated that some jobs for example were more suited for men, for example, such as being an engineer.

> *Kristján: You girls you're considering medicine?*
>
> *Ósk: I just can't see myself as some engineer*
>
> *Kristján: No*
>
> *Kristján: What does an engineer look like? Girls what do you think?*
>
> *Ari: I suppose that he stands in a yellow safety west with a helmet, pointing somewhere*
>
> *Kolla: I think it is a typical male job*

These examples are only few of many indications of attainment value in the interviews. Many of them have already been discussed in the previous chapters. The geeky perception of the scientists discussed in Chapter 5.2.3 for example can be seen as lowering the attainment value of becoming a scientist, with the exception that the learner sees himself or herself as a nerd and is living up to his or her self image by wanting to become a scientist. One of the boys in the interviews seemed to have that self-image. In an open ended item in the electronic questionnaire he justified his interest in science and the interest of his friends by labeling them as nerds.

> *Open ended item: Why or why not are they (the friends) interested in this (school science related things)?*
>
> *Karl: Because we are all a bit nerdy and we try to acquire knowledge about as many things as possible*

This indicates, in my opinion, that the attainment value of school science is dependent on the self-image of the learner involved, as suggested by the adapted model of achievement choices, and therefore the same school science can have high or low attainment value depending on the learner. The centrality of the self-image is clearly depicted in construct G ‘Learners’ Goals and General Self-Schemas’ (see Figure 3).

Intrinsic and interest Value

As described in Chapter 3.3.2 *intrinsic value* is reserved for the enjoyment one gains from doing the task or the anticipated enjoyment one expects to experience while doing the task. *The interest value* is learning that is driven by curiosity or interest.

Intrinsic value is very personal and related to the immediate subjective experience when people are engaged in the activity. This makes it hard to measure in group interviews as used in this research. The measurement of the intrinsic value would probably be best measured by individual interviews right after some science related assignment. Due to this, little information was available in the interviews on the role of intrinsic value in learners’ willingness to engage in science related activities.

Intrinsic value is amongst other things related to the term flow and the feeling of being in control of one’s actions and the environment. At one place in the interviews Ari talks about how he, different to most others, likes the hard content aspect of science. This has previously been quoted in Chapter 5.3.1. I suspect that Ari’s intrinsic value, as well most other parts of the STV, is relatively high as he probably feels that he has control over his actions in school science. Maybe the intrinsic value is something that learners appreciate when their willingness to engage in science is already firmly in place. As little information is available on the issue of intrinsic value amongst the learners interviewed this discussion will remain in the form of pure speculation.

The issue of interest has previously been discussed in relation to learner perceptions of school science in Chapter 5.2.1. Interest in school science was the highest rated item in section F of the ROSE questionnaire (see Table 4) and correlated strongly with a number of other items especially F4 ‘School science has opened my eyes to new and exciting jobs’ (see Table 5).

The learners in the interviews expressed their interest in science related issues to some extent. Ari for example talked about how interesting it was to hear about space exploration and new inventions in all sorts of fields. In one of the groups four out of six learners were subscribers to the Icelandic version of Popular Science Magazine. They talked about how interesting it was and how it raised their curiosity about unknown things.

Kristján: But what about for example you Kolla?

Árni: What fascinates you about it?

Kolla: The magazine?

Kristján: Yes

Kolla: I just like reading it. For example how big snakes can get

Unclear: You get to know about lots of stuff

Íris: There are so many things, like about babies and embryos, a lot of things interesting to read

Kolla: Yes, some archeological findings and skeletons

Kristján: What do you think about Discovery channel and such?

Kolla: I always watch Animal Planet

During the interviews I asked the learners to compare their interest in school science (Icelandic: náttúrufræði) and science and technology (Icelandic: vísindi og tækni). The technology aspect of the latter concept seemed unattractive to the girls and some of the boys. These learners considered school science to be interesting but their opinion of science and technology seemed contradictory. They seemed to be interested in science and technology but not in the sense of actively choosing to engage in it.

The interest aspect of discovery and design was indicated by some of the boys as they talked about how they would like to engage in a science related career if they could work with designing and improving products. One of the boys also mentioned the creation of stories in the development of computer games as interesting science related work.

This together with the strong relation of interest and exciting career opportunities makes me wonder if the creative side of science related careers is well enough presented to learners in general. Such a connection would probably coincide with the self-image of many learners in Iceland today and therefore would help in building the interest value component part of the STV.

Utility value

'Utility value' refers to how a task fits into an individual's future plans and is therefore closely related to attainment value. In my mind utility value is only a narrower and more precisely defined subvalue of the attainment value. The importance of attainment value, as previously discussed, was the most obvious trend emerging from the interview data and as a subvalue the utility value can also be found in various forms in the interview transcriptions.

When I asked the learners in one of the groups if they were considering continuing with science in the upper secondary school all of them agreed. This did not come as a surprise as the teacher had on my request chosen them because they were relatively good science learners. When asked why, the immediate reason on the learners' behalf was that the science option in upper secondary school left more doors open after graduation. The importance of the role of school science in increasing the learner choices in the future was confirmed by all the groups.

Kristján: Ok, bad question sorry, continue - are you thinking about continuing with school science?

All: Yes

Kristján: Everybody?

All: Yes

Kristján: Why?

Maja: It offers many opportunities, if you don't quite know what you want to do than it's best to choose science (náttúrufræði) than sociology or something

Kristján: So that matters a lot when you choose your trajectory in upper secondary school?

All: Yes

Some of the learners had already set their minds on a particular job which they considered to be exciting and rewarding. So studying science to them was more a means to an end rather than an end in itself.

Kolla: I want to be a doctor, so I've long ago decided to choose science in upper secondary school. And yes! And learn all about doctors, go to the United States and study.

Kristján: You are saying you want to study science (náttúrufræði) to become a doctor?

Kolla: Yes

Kristján: But do you find all the things taught in school science interesting?

Kolla: No

Kristján: You are mainly studying it for becoming a doctor?

Íris: Yes, I'm also going to do that, I'm very interested in science but there are some things, you know it's ok, but it's not my favorite subject, but I'm going to be a midwife, so I'm going to choose science (náttúrufræði).

The utility value emerged from the interview data as one of the strongest components of the STV but as I see it, it supports the importance of the attainment value rather then standing on its own as an individual component.

Perceived cost

As previously described in Chapter 3.3.2 perceived cost is said to be influenced by many factors, such as the loss of time and energy for other activities, anticipated anxiety, fear of failure, fear of the social consequences of success, such as rejection by peers, or anticipated sexual harassment or discrimination, or anger from one's parents or other key people, and fear of loss of a sense of self-worth.

As previously discussed in Chapter 5.3.1 studying science is associated with hard work and therefore considered *time-consuming*. Furthermore as discussed in Chapter 5.2.4 learners find it important for their future job to have lots of *time* for their friends. Therefore the perceived cost of engaging in science related issues might be considered high in many cases.

Some of learners complained over the large amount of content covered in the science classes. Many of them saw no point in studying things that were not going to be tested on the upcoming national exams. The perceived cost of studying large amounts of science content is in this case being considered high and therefore not contributing to increased willingness to engage in science related issues.

> *Ýr: So much content is being covered that some of it is not being taught well at all. We should rather have a bit less content and cover it better*
>
> *Ari: Yes*
>
> *Kristján: Cover less and better?*
>
> *Ýr: Yes, like some of the stuff we've been reading hasn't been on a national exam, or something*
>
> *Ósk: Maybe one doesn't understand the entire thing one reads in the school science text books*
>
> *Maja: Like in Physics we are doing way too much of those assignments that need calculations, like we were saying, not so much comes on the national exam, and we are always calculating and such, but he (the teacher) just thinks that there should be a lot of calculating and therefore he just does it, or you know. He said that there would not be so much of this on the national exam*
>
> *Kristján: Do you think there is too much of that?*
>
> *Ósk: In his class, he's not teaching stuff directly from the book we are reading*

Another thing that can be read from this quote is the fear of failure on the national exam. In Iceland the grade on the national exam in 10th grade limits choice in upper secondary school during the first semester. Furthermore the school average is made public and the media ranks schools from winners to losers according to the outcome on the national exams. The perceived cost of being a failure in science is therefore often considered high and many learners come up with innovative survival techniques to avoid the appearance of a lack of ability, including procrastination, making excuses, avoiding challenging tasks, and not trying (see Chapter 3.3.2). The negative perception that school science and science and technology are nothing more than just formulas and calculations indicated by Ósk (see Chapter 5.2.1) probably originates from her own strategy of avoiding the appearance of lack of ability by indicating that formulas and calculations are boring and not important for her. The unappealing image of mathematics due to hard work is in agreement with the findings of VanLeuvan (2004) reviewed in Chapter 2.1.

In general I think learner perceived cost of engaging in science related issues was surprisingly high among the learners interviewed, given the fact that almost all of them were considering studying science for various reasons. As a member of the Icelandic society and as a product of the Icelandic school system I can fully agree that science together with mathematics is uppermost when it is up to the public to point out the most demanding school subject. This raises a question. Does society benefit from having an elite subject where the perceived cost of engaging in it is higher than in others? I do not think so. In my opinion 'science for all' should be affordable for all regardless of the perceived cost of the subject.

6. Discussion and conclusions

6.1 Discussion of results

Perception of school science

During the interviews and in the analysis of the ROSE data some things related to learner perceptions of school science stood out as things that might be of help in improving teaching and learning in that area. First it might be useful to have in mind that when the learners talked about school science (náttúrufræði) the term was perceived differently than the perception one gets by reading the national curricula. School science was largely related to biology and the medical profession, something that most probably is transmitted through the ideas of their socializers such as teachers, parents and friends.

The way science is taught was perceived by learners as depending highly on each teacher involved. Learners often expressed pragmatic views on teaching and learning where practical work, discussions and non-traditional teaching methods were often described as impractical for getting high marks on the national exams at the end of 10^{th} grade. Despite this, when learners were asked for their recommendations for better school science, all mentioned more practical work and less content steered curricula as their number one recommendations.

The results showed that learners generally found school science interesting, relevant and important for all. Despite this few learners were interested in having as much science at school as possible. The current amount of school science in the curricula was generally perceived as appropriate.

The strong positive relationship between ‘school science being a career opener’ and ‘learners being interested in science’ supported the clear wish on behalf of the learners to visit more workplaces and of getting into contact with real life science.

The strong positive relationship between ‘school science being easy to learn’ and a number of other attitude related items gave support to the importance of self-efficacy described in Chapter 3.4. The learners were split in their opinion of whether everybody should learn science at school.

Perception of science and technology

Learners in the interviews seemed to relate science and technology mostly to machines and invention. These inventions were often perceived as of no real importance such as smaller phones and better mp3-players. This has led me to believe that the learners’ definition of the term science and technology is quite narrow in many cases and object related. The quantitative data also suggests that learners perceive science as very important for society but not necessarily for everybody to learn. This could be due to the narrow definition of science and technology transmitted to learners through various channels.

Learners interviewed seemed aware of the role that the media play in forming perceptions and meanings. Most learners were able to reflect critically on the science and technology image portrayed by various media sources. The ROSE data also indicated that most Icelandic learners seem to have developed an attitude of critical reflection towards science and technology issues.

At the same time as learners did not agree to statements that indicated unconditional trust towards science and technology the same learners placed high beliefs in science and technology to solve the threats that face mankind. Learners did not put all their trust on science and technology as a large majority of the learners disagreed with the statement ‘Science and technology will solve all problems’. A gender difference could be noticed where girls were not as willing as boys to depend on science and technology to solve all problems.

Some learners interviewed showed signs of polarized views towards science and technology in a way that science and technology were depicted as necessary at the same time as it was described as the source of feelings of incompetence among learners. That is interesting seen in the light that learners interviewed generally did well in science according to their teacher.

Learners had problems relating science and technology to any Icelandic companies and possible careers. The companies that eventually were mentioned were not regarded as attractive work places due to several reasons such as impersonal atmosphere or little time for family and friends. Although generally regarded as unattractive workplaces, the importance of those companies for the national economy was generally high in the minds of learners interviewed. In my mind this is an example of how the social environment and the learners’ socializers shape learners’ meanings about science and technology related issues when the learner does not seem to have any first hand experience of the issue under consideration.

Perception of scientists

The term scientist seemed to have an unattractive meaning according to learners that participated in the interviews. The scientist was male, in a white coat, middle aged, strange looking, and all knowing, distracted and a bit geeky. The unattractiveness of the profession was confirmed in the ROSE data where 75% of the learners disagreed to some extent that they would like to become scientists.

When asked in the interviews very few learners thought they knew any scientists. Doctors, engineers and people working in biogenetics were not considered to be scientists in the proper meaning of the word, according to most learners in the interviews. If these and other professions were included in the definition of the word scientist learners came up with the names of many scientists which they knew.

According to the interviews, the scientist was considered in *his* profession to work with invention. He was considered helping people in an indirect manner by making life easier by inventing new things that were not always necessary. This was seen as a contrast to the medical profession where the doctors help people directly and get their recognition instantly.

The ROSE data revealed that a majority of the learners disagreed with statements that indicated unconditional trust towards scientists. I regard this as positive as this indicates that the learners are capable of critical reflection about what scientists have to say.

The unattractiveness of becoming a scientist and the narrow interpretation of the term scientist leads me to believe that the term ‘scientist’ is more related to what seems to be an uninspiring technological dimension of the term while the definition of the term ‘science and technology’ seems more complex and seems to be related to a wider field of interest.

Perception of scientific careers

The emphasis on the medical profession as an attractive science related career was noticeable during the interviews. The arguments for this attractiveness were that it was fun, rewarding, important, had good salaries and was fascinating. Many learners indicated an unrealistic image of their preferred future careers and repeatedly wished for more information about science related professions.

Learners in the interviews ranked TV as their main source of information about scientific careers followed by the internet and their parents. They indicated capabilities of critical reflection of the information they received through television and other media. All of the groups failed to mention the career counselor as a source of information regarding scientific careers. When the learners were asked directly they connected the work of the career counselor to the upcoming choice of an upper secondary school and an appropriate choice of learning trajectory.

Much of the discussion during the interviews was devoted to what learners found generally important for their future career. In addition to previously mentioned issues of helping people and decent salaries the learners repeatedly mentioned that the work had to be fun. Some of the learners elaborated this argument by saying the work had to be fun as it was such a big part of life, and everybody wanted to live a fun life. The learners mentioned the importance of long holidays and good social atmosphere in the work place as important.

The ROSE data indicated that boys and girls were in unison about the importance of self-realizing factors of the future job that were found in the group interviews. One item especially, item B12 ‘Having lots of time for my friends’ stood out as the only item in section B that had a strong *positive* correlation to the Human Development Index, indicating the high importance of ‘having lots of time for friends’ for learners in countries with high human development indices.

Items that included traditional gender related job characteristics such as working with machines or tools and helping people were the source of the main gender difference in the section. The distribution indicated that the girls were generally more unanimous in their response than boys. I choose to interpret this as the girls being more aware of the traditional gender roles most probably due to external press from their socializers and the social environment.

In short I can say that learners placed high demands to their future profession. They saw their future work as a part of themselves and as an important part of living a fun and meaningful life.

Expectation of success

Although the main focus of this thesis is on learner perceptions of science related issues, the centrality of its relation to learner expectations of success cannot be left untouched. Expectation of success is a complex term but I chose to measure it in one of its simplest forms, that is, by measuring subject-specific self-efficacy.

The overall self-efficacy was high both among boys and girls. This was not surprising as the learners were chosen by their teachers on the premises that they were relatively good in science and not afraid to express their opinion. In the small sample of seventeen learners, the majority of the girls had lower means then the boys, indicating lower self-efficacy. These results call for further studies.

When comparing the interview transcripts a theme of negative perception of science related issues emerged amongst learners with low self-efficacy. The learners with high self-efficacy seemed also more willing to express their enthusiasm with regard to issues related to science.

The important role of friends came up for the second time in this research (see also Chapter 5.2.4) as five of the top six learners with highest scores on the self-efficacy measures indicated that their friends were interested in science related issues. The other 12 learners either said that most of their friends were not interested in science related issues or did not give enough information for them to be situated in either of the two groups.

The general acceptance of science being a hard subject seemed to reinforce the self-efficacy beliefs of some learners, creating higher high self-efficacy and lower low self-efficacy. The range of measured self-efficacy in the group came as a surprise as all of the learners were, according to their teachers, ‘good’ science learners.

The two learner examples in the chapter are far from the only examples of learners that show perceptions that, to my mind, are related to differences in expectation of success. In general my experience of interviewing all the learners and comparing this data with learner expectations of success has strengthened my belief that expectation of success is indeed related to learner perceptions of science related issues and, more importantly willingness to engage in those issues.

The examples in this summary can be seen as important indicators that call for further research on the role of expectation of success in the Icelandic school science context. The relationship between the perceptions of science related issues and the willingness to engage in those issues, as described in the adapted model of achievement related choices, is in my opinion supported by these examples rather then rejected.

Subjective task value

The purpose of Chapter 5.3.2 was to highlight the results and the discussion related to learner perceptions as proposed in the adapted model of achievement related choices by relating them to the learners’ subjective task value (STV). The intention was to reveal the strengths and limitations of studying learner perceptions towards science related issues.

Of the four STV components the attainment value emerged as the strongest theme in the interview data. Some of the learners indicated that a science related career was not consistent with their self-image. The need to feel that what one does matters in a fundamental and important way and the need to feel respected is also evident. One learner pointed out that everybody knew the doctor that helped them but nobody knew who the scientist was that invented something helpful. The proper role of people was also given as an example of the attainment value as one girl did not find an engineering job properly suited for females.

Little information could be found about the role of the intrinsic value in learner willingness to engage in science related issues. This might be due to the method used in collecting the data. The personal nature of the intrinsic value suggests that individual interviews are needed in research of the intrinsic value of engaging in science related issues.

On the other hand learners repeatedly talked about interest value. Their interest for science seemed firmly in place as has also been confirmed by ROSE data in Chapter 5.2.2. This came through amongst other things in their interest in popular science and science related TV programs as well as computers. When learners were asked about their opinion about school science most of the learners were interested in it. When the learners were asked about their interest in school science and their interest in science and technology in general some of the learners, especially the girls, indicated a preference for school science rather than science and technology in general. The technology aspect of the latter did not seem to be consistent with the self-image of these learners.

The interest aspect of discovery and design was indicated by some of the boys as they talked about how they would like to engage in a science related career if they could work with designing and improving products. One of the boys also mentioned the creation of stories in the development of computer games as an interesting science related work. This together with the strong relation of interest and exciting career opportunities makes me wonder if the creative side of science related careers is well enough presented to learners in general. Such a connection would probably coincide with the self-image of many learners in Iceland today and therefore would help in building the interest value component part of the STV.

The utility value emerged from the interview data as an important aspect. The importance of school science increasing the learners' choice upon upper secondary school graduation came up during all the group interviews. Many learners indicated also that they had already set their minds on a particular job which they considered to be exciting and rewarding. So studying science to them was more a means to an end rather than an end in itself.

The perceived cost of engaging in science related issues was in my opinion surprisingly high considering that the learners were, according to their teachers, dedicated science learners. Science was considered by the learners to be a difficult and time-consuming subject. Criticism was raised about the large amount of content in the science curricula and teachers were encouraged to teach the content that was most likely to come up on the upcoming national exam. The perceived cost of being a failure in science was high and strategies developed by the learners to avoid the appearance of a lack of ability came up during the interviews. At the end of the discussion of the perceived cost the following question was raised:

> *Does the society benefit from having an elite subject where the perceived cost of engaging in it is higher than in others?*

I do not think so. In my opinion 'science for all' should be affordable for all regardless of the perceived cost of the subject.

6.2 Reflections

At this time in the thesis it is worthwhile looking back at the initial research question described and stated in Chapter 3. The research question was divided into two parts ‘How do learner perceptions of science related issues relate to their willingness to engage in those issues’ and ‘what do we know about these perceptions in the context of Icelandic learners?’. In my attempt to answer the first part I realized that the research in this area was limited and I was not able to find any conceptual framework that suited the data I started with. This resulted in the adaptation and application of the model of achievement related choices made by Eccles (2005) and colleagues described in this thesis. The validity of this adaptation can only be answered through further research in the area, which is undoubtedly needed. The second part of the research question was answered by presenting and discussing results obtained by the ROSE questionnaire and the group interviews (see Chapter 5). I will now elaborate my conclusion by discussing the use of the adapted model including its various components followed by a brief list of implications.

A short review of recent literature in Chapter 2 did not provide me with the conceptual framework needed for studying learner perceptions of science related issues and their relation to the willingness to engage in those issues. The review gave me the impression that previous studies have focused mainly on single achievement or perception constructs and therefore did not reveal how these constructs are connected or the importance of other social and psychological constructs. The model of achievement related choices however offered a framework that situated the learner perceptions in an interconnecting loop in relation to the learner achievement choices. The adaptation of this model and the argumentation for this adaptation became a large part of this research.

I chose to adapt the model and narrow its scope from general expectancy to the expectancy of engaging in science related issues called the ‘willingness to engage in science related issues’ as defined by PISA (see Figure 3). According to the adapted model the learner perceptions emerge from their social environment and their socializers' beliefs and behaviors. The importance of the social environment was specially addressed in Chapter 5.1. The strong correlation between items related to learner perceptions of science related issues and the human development index (HDI) was used as an argument for the importance of the social environment in determining learner perceptions. Although not addressed separately, the importance of socializers' beliefs and behaviors was also evident in the data with regard to the importance of friends and parents in forming or maintaining perceptions of science related issues.

As my data was limited I chose to concentrate on four perceptions adapted out of five dispositions towards science related issues identified in the research literature by Bennett (2003) (see Chapter 2.4). These four perceptions are:

- Perception of school science,
- Perception of science and technology,
- Perception of scientists, and
- Perception of scientific careers,

These perceptions seemed to function as separate factors and reveal some of the reasons learners' choose or choose not to engage in science related issues. According to the adapted model the learner perceptions supposedly shape 'Learners' Goals and General Self-Schemas' and 'Learners' Affective Reactions and Memories'. Arguments that support this connection came later when I studied the learners' willingness to engage in science related issues in Chapter 5.3.

The purpose of Chapter 5.3 was to highlight the results on learner perceptions with regard to the adapted model of achievement related choices, in particular by studying the willingness to engage in science related issues. Achievement choices and performance are considered by Eccles (2005) and colleagues to be directly related to the expectation of success and the subjective task value as described in Chapter 3.3. The numerous connections made between these constructs (Chapter 5.3) and learner perceptions of science related issues (Chapter 5.2) have in my opinion contributed to a more nuanced understanding of the role that learner perceptions of science related issues play in their willingness to engage in those issues. This has furthermore revealed the complexity of the issue and the need for more research in the area.

This thesis draws on an abundance of research data that have not been followed up in-depth by a detailed discussion. One example of this, in my opinion, is the strong correlation between the human development index (HDI) and the learner perceptions of science related issues which was described in Chapter 5.1. These are results that can be interpreted as strong evidence for the relation of the social environment and learner willingness to engage in science related issues. During the research I consciously tried not to be diverted from the research question by individual results like these.

The first part of my research question 'How do learner perceptions of science related issues relate to willingness to engage in those issues?' was initially formulated because interesting results of different items in the ROSE questionnaire lacked in my opinion a conceptual framework for their interpretation and therefore the data was not working as an argument towards any possible practical implications. This led me to what I consider to be the most important contribution this research has made, i.e. to open a discussion about the use of the model in looking at young people's choices in science related areas. The research has taken some initial steps in creating a conceptual framework for the willingness to engage in science related issues. An argument for this framework has been established and groundwork has been laid for further research. The results have suggested how the adapted model of achievement choices (see Chapter 3.4) could by used as a comprehensive tool in assessing how learner perceptions of science related issues affect their willingness to engage in those issues.

6.3 Implications

During the adaptation and application of the model of achievement related choices (Eccles, 2005) a number of possible implications of my findings emerged. These belong to different constructs but are all related in one way or another in the adapted model (see Figure 3).

- Firstly the model of achievement choices provided a useful insight in factors that influence young peoples' choices in regards to their science related achievement choices. The different components of the subjective task value (STV) can together with expectations of success indicate useful didactic and pedagogic approaches in the teaching and learning of science. An implication for science teachers could be *systematic interactions with learners with the aim of increasing learner expectations of success.* The data together with the adapted model suggest that such interactions could, in some cases, lead to a positive spiral effect that result in an increase in the learners' willingness to engage in science related issues. Research on enhancing self-efficacy could be useful in this case.

- In the discussion about learner perceptions and the attainment value I came across the negative effects of labeling. By labeling those who engage in science as super-smart we heighten the perceived threshold into the world of science. Learners feel that they are incompetent in spite of good grades and feel they have to associate with nerds to publicly admit liking science. Implication from these findings might be in the form of *breaking down barriers and giving more learners the feeling that being competent in science is a worthwhile option.*

- In the discussion about school science the learners were divided in their opinion of whether everybody should learn science at school. These results create a good *opportunity for an open discussion in Iceland, amongst teachers and learners, about the purpose of school science and whether or not it should be obligatory for all.* Such a discussion could spin off into a discussion of science, democracy and citizenship and provide Icelandic learners with a valuable learning experience.

- Learner perceptions of scientific careers together with their attainment values indicated that images of these careers were often unclear or distorted in some way. Implications could involve introducing workplaces to learners where girls work with machines and tools and showing learners how science related professions deal with fundamentally important things and receive direct public recognition. Similarly the creative side of scientific jobs should be emphasized. This can *help inform learners so their perception of what is important for their future job can develop.*

- The importance of friends to the Icelandic learner gives reason to make teachers and parents aware of the extent to which it is socially appropriate to engage in science. The implications for teachers might be to *adapt their science teaching to different social realities in each classroom.* For example with custom-made teaching where learners with different perceptions could have the opportunity to flourish and maybe broaden their views.

- In my discussion of perceptions of science and technology and the attainment value I asked myself whether the current image of science and technology related studies transmit the message of being the trajectory to a fun and meaningful life. It is my distinct notion after the interviews that this is not always the case. I believe that many learners place demands on their future lives that the current image of science and technology is not able to fulfill. I also believe that many things can be done to change the image of science and technology and school science. *Increased cooperation between schools and science related institutions such as environmental organizations, industry and museums together with practical work inspired by real life professions could help learners and their socializers to fine-tune their general perceptions of science* in a way that could help to increase learner willingness to engage in science related issues as a reflective citizen.

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Appendix

ROSE
The Relevance of Science Education

This booklet has questions about you, and about your experiences and interests related to science in school and outside school.

There are no correct or incorrect answers, only answers that are right for you.
Please think carefully and give answers that reflect your own thinking.

This questionnaire is being given to students in many different countries. That is why some questions may seem strange to you. If there is a question you do not understand, just leave it blank. If you are in doubt, you may ask the teacher, since this is not a test!

For most questions, you simply put a tick in the appropriate box.

The purpose of this questionnaire is to find out what students in different parts of the world think about science at school as well as in their everyday life. This information may help us to make schools better.

Your answers are anonymous, so please, do not write your name on this questionnaire.

THANK YOU!
Your answers will be a big help.

START HERE:

I am a ☐ girl ☐ boy

I am _____ years old

I live in __________________ (write the name of your country)

Contact and ©: Professor Svein Sjøberg, ILS, University of Oslo,
PO Box 1099 Blindern, 0317 Oslo, Norway
tel: +47 22 85 41 55, fax: +47 22 85 44 09, e-mail: svein.sjoberg@ils.uio.no

A. What I want to learn about

How interested are you in learning about the following?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Not interes-ted			*Very interes-ted*
1.	Stars, planets and the universe	☐	☐	☐	☐
2.	Chemicals, their properties and how they react	☐	☐	☐	☐
3.	The inside of the earth	☐	☐	☐	☐
4.	How mountains, rivers and oceans develop and change	☐	☐	☐	☐
5.	Clouds, rain and the weather	☐	☐	☐	☐
6.	The origin and evolution of life on earth	☐	☐	☐	☐
7.	How the human body is built and functions	☐	☐	☐	☐
8.	Heredity, and how genes influence how we develop	☐	☐	☐	☐
9.	Sex and reproduction	☐	☐	☐	☐
10.	Birth control and contraception	☐	☐	☐	☐
11.	How babies grow and mature	☐	☐	☐	☐
12.	Cloning of animals	☐	☐	☐	☐
13.	Animals in other parts of the world	☐	☐	☐	☐
14.	Dinosaurs, how they lived and why they died out	☐	☐	☐	☐
15.	How plants grow and reproduce	☐	☐	☐	☐
16.	How people, animals, plants and the environment depend on each other	☐	☐	☐	☐
17.	Atoms and molecules	☐	☐	☐	☐
18.	How radioactivity affects the human body	☐	☐	☐	☐
19.	Light around us that we cannot see (infrared, ultraviolet)	☐	☐	☐	☐
20.	How animals use colours to hide, attract or scare	☐	☐	☐	☐
21.	How different musical instruments produce different sounds	☐	☐	☐	☐
22.	Black holes, supernovas and other spectacular objects in outer space	☐	☐	☐	☐
23.	How meteors, comets or asteroids may cause disasters on earth	☐	☐	☐	☐

		Not interested			*Very interested*
24.	Earthquakes and volcanoes	☐	☐	☐	☐
25.	Tornados, hurricanes and cyclones	☐	☐	☐	☐
26.	Epidemics and diseases causing large losses of life	☐	☐	☐	☐
27.	Brutal, dangerous and threatening animals	☐	☐	☐	☐
28.	Poisonous plants in my area	☐	☐	☐	☐
29.	Deadly poisons and what they do to the human body	☐	☐	☐	☐
30.	How the atom bomb functions	☐	☐	☐	☐
31.	Explosive chemicals	☐	☐	☐	☐
32.	Biological and chemical weapons and what they do to the human body	☐	☐	☐	☐
33.	The effect of strong electric shocks and lightning on the human body	☐	☐	☐	☐
34.	How it feels to be weightless in space	☐	☐	☐	☐
35.	How to find my way and navigate by the stars	☐	☐	☐	☐
36.	How the eye can see light and colours	☐	☐	☐	☐
37.	What to eat to keep healthy and fit	☐	☐	☐	☐
38.	Eating disorders like anorexia or bulimia	☐	☐	☐	☐
39.	The ability of lotions and creams to keep the skin young	☐	☐	☐	☐
40.	How to exercise to keep the body fit and strong	☐	☐	☐	☐
41.	Plastic surgery and cosmetic surgery	☐	☐	☐	☐
42.	How radiation from solariums and the sun might affect the skin	☐	☐	☐	☐
43.	How the ear can hear different sounds	☐	☐	☐	☐
44.	Rockets, satellites and space travel	☐	☐	☐	☐
45.	The use of satellites for communication and other purposes	☐	☐	☐	☐
46.	How X-rays, ultrasound, etc. are used in medicine	☐	☐	☐	☐
47.	How petrol and diesel engines work	☐	☐	☐	☐
48.	How a nuclear power plant functions	☐	☐	☐	☐

B. My future job

How important are the following issues for your potential future occupation or job?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Not important			*Very important*
1.	Working with people rather than things	☐	☐	☐	☐
2.	Helping other people	☐	☐	☐	☐
3.	Working with animals	☐	☐	☐	☐
4.	Working in the area of environmental protection	☐	☐	☐	☐
5.	Working with something easy and simple	☐	☐	☐	☐
6.	Building or repairing objects using my hands	☐	☐	☐	☐
7.	Working with machines or tools	☐	☐	☐	☐
8.	Working artistically and creatively in art	☐	☐	☐	☐
9.	Using my talents and abilities	☐	☐	☐	☐
10.	Making, designing or inventing something	☐	☐	☐	☐
11.	Coming up with new ideas	☐	☐	☐	☐
12.	Having lots of time for my friends	☐	☐	☐	☐
13.	Making my own decisions	☐	☐	☐	☐
14.	Working independently of other people	☐	☐	☐	☐
15.	Working with something I find important and meaningful	☐	☐	☐	☐
16.	Working with something that fits my attitudes and values	☐	☐	☐	☐
17.	Having lots of time for my family	☐	☐	☐	☐
18.	Working with something that involves a lot of travelling	☐	☐	☐	☐
19.	Working at a place where something new and exciting happens frequently	☐	☐	☐	☐
20.	Earning lots of money	☐	☐	☐	☐
21.	Controlling other people	☐	☐	☐	☐
22.	Becoming famous	☐	☐	☐	☐
23.	Having lots of time for my interests, hobbies and activities	☐	☐	☐	☐
24.	Becoming 'the boss' at my job	☐	☐	☐	☐
25.	Developing or improving my knowledge and abilities	☐	☐	☐	☐
26.	Working as part of a team with many people around me	☐	☐	☐	☐

C. What I want to learn about

How interested are you in learning about the following?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Not interes-ted			*Very interes-ted*
1.	How crude oil is converted to other materials, like plastics and textiles	☐	☐	☐	☐
2.	Optical instruments and how they work (telescope, camera, microscope, etc.)	☐	☐	☐	☐
3.	The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	☐	☐	☐	☐
4.	How cassette tapes, CDs and DVDs store and play sound and music	☐	☐	☐	☐
5.	How things like radios and televisions work	☐	☐	☐	☐
6.	How mobile phones can send and receive messages	☐	☐	☐	☐
7.	How computers work	☐	☐	☐	☐
8.	The possibility of life outside earth	☐	☐	☐	☐
9.	Astrology and horoscopes, and whether the planets can influence human beings	☐	☐	☐	☐
10.	Unsolved mysteries in outer space	☐	☐	☐	☐
11.	Life and death and the human soul	☐	☐	☐	☐
12.	Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	☐	☐	☐	☐
13.	Why we dream while we are sleeping, and what the dreams may mean	☐	☐	☐	☐
14.	Ghosts and witches, and whether they may exist	☐	☐	☐	☐
15.	Thought transference, mind-reading, sixth sense, intuition, etc.	☐	☐	☐	☐
16.	Why the stars twinkle and the sky is blue	☐	☐	☐	☐
17.	Why we can see the rainbow	☐	☐	☐	☐
18.	Properties of gems and crystals and how these are used for beauty	☐	☐	☐	☐

D. Me and the environmental challenges

To what extent do you agree with the following statements about problems with the environment (pollution of air and water, overuse of resources, global changes of the climate etc.)? (Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Disagree			*Agree*
1.	Threats to the environment are not my business	☐	☐	☐	☐
2.	Environmental problems make the future of the world look bleak and hopeless	☐	☐	☐	☐
3.	Environmental problems are exaggerated	☐	☐	☐	☐
4.	Science and technology can solve all environmental problems...	☐	☐	☐	☐
5.	I am willing to have environmental problems solved even if this means sacrificing many goods	☐	☐	☐	☐
6.	I can personally influence what happens with the environment ..	☐	☐	☐	☐
7.	We can still find solutions to our environmental problems	☐	☐	☐	☐
8.	People worry too much about environmental problems	☐	☐	☐	☐
9.	Environmental problems can be solved without big changes in our way of living	☐	☐	☐	☐
10.	People should care more about protection of the environment ...	☐	☐	☐	☐
11.	It is the responsibility of the rich countries to solve the environmental problems of the world	☐	☐	☐	☐
12.	I think each of us can make a significant contribution to environmental protection..	☐	☐	☐	☐
13.	Environmental problems should be left to the experts	☐	☐	☐	☐
14.	I am optimistic about the future	☐	☐	☐	☐
15.	Animals should have the same right to life as people	☐	☐	☐	☐
16.	It is right to use animals in medical experiments if this can save human lives	☐	☐	☐	☐
17.	Nearly all human activity is damaging for the environment	☐	☐	☐	☐
18.	The natural world is sacred and should be left in peace.............	☐	☐	☐	☐

E. What I want to learn about

How interested are you in learning about the following?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Not interes-ted			*Very interes-ted*
1.	Symmetries and patterns in leaves and flowers	☐	☐	☐	☐
2.	How the sunset colours the sky	☐	☐	☐	☐
3.	The ozone layer and how it may be affected by humans	☐	☐	☐	☐
4.	The greenhouse effect and how it may be changed by humans	☐	☐	☐	☐
5.	What can be done to ensure clean air and safe drinking water ..	☐	☐	☐	☐
6.	How technology helps us to handle waste, garbage and sewage	☐	☐	☐	☐
7.	How to control epidemics and diseases	☐	☐	☐	☐
8.	Cancer, what we know and how we can treat it	☐	☐	☐	☐
9.	Sexually transmitted diseases and how to be protected against them	☐	☐	☐	☐
10.	How to perform first-aid and use basic medical equipment	☐	☐	☐	☐
11.	What we know about HIV/AIDS and how to control it	☐	☐	☐	☐
12.	How alcohol and tobacco might affect the body	☐	☐	☐	☐
13.	How different narcotics might affect the body	☐	☐	☐	☐
14.	The possible radiation dangers of mobile phones and computers	☐	☐	☐	☐
15.	How loud sound and noise may damage my hearing	☐	☐	☐	☐
16.	How to protect endangered species of animals	☐	☐	☐	☐
17.	How to improve the harvest in gardens and farms	☐	☐	☐	☐
18.	Medicinal use of plants	☐	☐	☐	☐
19.	Organic and ecological farming without use of pesticides and artificial fertilizers	☐	☐	☐	☐
20.	How energy can be saved or used in a more effective way	☐	☐	☐	☐
21.	New sources of energy from the sun, wind, tides, waves, etc. ...	☐	☐	☐	☐
22.	How different sorts of food are produced, conserved and stored	☐	☐	☐	☐
23.	How my body grows and matures	☐	☐	☐	☐

		Not interes-ted			*Very interes-ted*
24.	Animals in my area	☐	☐	☐	☐
25.	Plants in my area	☐	☐	☐	☐
26.	Detergents, soaps and how they work	☐	☐	☐	☐
27.	Electricity, how it is produced and used in the home	☐	☐	☐	☐
28.	How to use and repair everyday electrical and mechanical equipment	☐	☐	☐	☐
29.	The first landing on the moon and the history of space exploration	☐	☐	☐	☐
30.	How electricity has affected the development of our society	☐	☐	☐	☐
31.	Biological and human aspects of abortion	☐	☐	☐	☐
32.	How gene technology can prevent diseases	☐	☐	☐	☐
33.	Benefits and possible hazards of modern methods of farming	☐	☐	☐	☐
34.	Why religion and science sometimes are in conflict	☐	☐	☐	☐
35.	Risks and benefits of food additives	☐	☐	☐	☐
36.	Why scientists sometimes disagree	☐	☐	☐	☐
37.	Famous scientists and their lives	☐	☐	☐	☐
38.	Big blunders and mistakes in research and inventions	☐	☐	☐	☐
39.	How scientific ideas sometimes challenge religion, authority and tradition	☐	☐	☐	☐
40.	Inventions and discoveries that have changed the world	☐	☐	☐	☐
41.	Very recent inventions and discoveries in science and technology	☐	☐	☐	☐
42.	Phenomena that scientists still cannot explain	☐	☐	☐	☐

F. My science classes

To what extent do you agree with the following statements about the science that you may have had at school?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Disagree			*Agree*
1.	School science is a difficult subject	☐	☐	☐	☐
2.	School science is interesting	☐	☐	☐	☐
3.	School science is rather easy for me to learn	☐	☐	☐	☐
4.	School science has opened my eyes to new and exciting jobs	☐	☐	☐	☐
5.	I like school science better than most other subjects	☐	☐	☐	☐
6.	I think everybody should learn science at school	☐	☐	☐	☐
7.	The things that I learn in science at school will be helpful in my everyday life	☐	☐	☐	☐
8.	I think that the science I learn at school will improve my career chances	☐	☐	☐	☐
9.	School science has made me more critical and sceptical	☐	☐	☐	☐
10.	School science has increased my curiosity about things we cannot yet explain	☐	☐	☐	☐
11.	School science has increased my appreciation of nature	☐	☐	☐	☐
12.	School science has shown me the importance of science for our way of living	☐	☐	☐	☐
13.	School science has taught me how to take better care of my health	☐	☐	☐	☐
14.	I would like to become a scientist	☐	☐	☐	☐
15.	I would like to have as much science as possible at school	☐	☐	☐	☐
16.	I would like to get a job in technology	☐	☐	☐	☐

G. My opinions about science and technology

To what extent do you agree with the following statements?

(Give your answer with a tick on each row. If you do not understand, leave the line blank.)

		Disagree			*Agree*
1.	Science and technology are important for society	☐	☐	☐	☐
2.	Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	☐	☐	☐	☐
3.	Thanks to science and technology, there will be greater opportunities for future generations	☐	☐	☐	☐
4.	Science and technology make our lives healthier, easier and more comfortable	☐	☐	☐	☐
5.	New technologies will make work more interesting	☐	☐	☐	☐
6.	The benefits of science are greater than the harmful effects it could have	☐	☐	☐	☐
7.	Science and technology will help to eradicate poverty and famine in the world	☐	☐	☐	☐
8.	Science and technology can solve nearly all problems	☐	☐	☐	☐
9.	Science and technology are helping the poor	☐	☐	☐	☐
10.	Science and technology are the cause of the environmental problems	☐	☐	☐	☐
11.	A country needs science and technology to become developed	☐	☐	☐	☐
12.	Science and technology benefit mainly the developed countries	☐	☐	☐	☐
13.	Scientists follow the scientific method that always leads them to correct answers	☐	☐	☐	☐
14.	We should always trust what scientists have to say	☐	☐	☐	☐
15.	Scientists are neutral and objective	☐	☐	☐	☐
16.	Scientific theories develop and change all the time	☐	☐	☐	☐

H. My out-of-school experiences

How often have you done this outside school?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)
I have ...

		Never			*Often*
1.	tried to find the star constellations in the sky	☐	☐	☐	☐
2.	read my horoscope (telling future from the stars)	☐	☐	☐	☐
3.	read a map to find my way	☐	☐	☐	☐
4.	used a compass to find direction	☐	☐	☐	☐
5.	collected different stones or shells	☐	☐	☐	☐
6.	watched (not on TV) an animal being born	☐	☐	☐	☐
7.	cared for animals on a farm	☐	☐	☐	☐
8.	visited a zoo	☐	☐	☐	☐
9.	visited a science centre or science museum	☐	☐	☐	☐
10.	milked animals like cows, sheep or goats	☐	☐	☐	☐
11.	made dairy products like yoghurt, butter, cheese or ghee	☐	☐	☐	☐
12.	read about nature or science in books or magazines	☐	☐	☐	☐
13.	watched nature programmes on TV or in a cinema	☐	☐	☐	☐
14.	collected edible berries, fruits, mushrooms or plants	☐	☐	☐	☐
15.	participated in hunting	☐	☐	☐	☐
16.	participated in fishing	☐	☐	☐	☐
17.	planted seeds and watched them grow	☐	☐	☐	☐
18.	made compost of grass, leaves or garbage	☐	☐	☐	☐
19.	made an instrument (like a flute or drum) from natural materials	☐	☐	☐	☐
20.	knitted, weaved, etc	☐	☐	☐	☐
21.	put up a tent or shelter	☐	☐	☐	☐
22.	made a fire from charcoal or wood	☐	☐	☐	☐
23.	prepared food over a campfire, open fire or stove burner............	☐	☐	☐	☐
24.	sorted garbage for recycling or for appropriate disposal	☐	☐	☐	☐
25.	cleaned and bandaged a wound	☐	☐	☐	☐
26.	seen an X-ray of a part of my body	☐	☐	☐	☐

	Never			Often
27. taken medicines to prevent or cure illness or infection	☐	☐	☐	☐
28. taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.)	☐	☐	☐	☐
29. been to a hospital as a patient	☐	☐	☐	☐
30. used binoculars	☐	☐	☐	☐
31. used a camera	☐	☐	☐	☐
32. made a bow and arrow, slingshot, catapult or boomerang	☐	☐	☐	☐
33. used an air gun or rifle	☐	☐	☐	☐
34. used a water pump or siphon	☐	☐	☐	☐
35. made a model such as toy plane or boat etc	☐	☐	☐	☐
36. used a science kit (like for chemistry, optics or electricity)	☐	☐	☐	☐
37. used a windmill, watermill, waterwheel, etc	☐	☐	☐	☐
38. recorded on video, DVD or tape recorder	☐	☐	☐	☐
39. changed or fixed electric bulbs or fuses	☐	☐	☐	☐
40. connected an electric lead to a plug etc.	☐	☐	☐	☐
41. used a stopwatch	☐	☐	☐	☐
42. measured the temperature with a thermometer	☐	☐	☐	☐
43. used a measuring ruler, tape or stick	☐	☐	☐	☐
44. used a mobile phone	☐	☐	☐	☐
45. sent or received an SMS (text message on mobile phone)	☐	☐	☐	☐
46. searched the internet for information	☐	☐	☐	☐
47. played computer games	☐	☐	☐	☐
48. used a dictionary, encyclopaedia, etc. on a computer	☐	☐	☐	☐
49. downloaded music from the internet	☐	☐	☐	☐
50. sent or received e-mail	☐	☐	☐	☐
51. used a word processor on the computer	☐	☐	☐	☐
52. opened a device (radio, watch, computer, telephone, etc.) to find out how it works	☐	☐	☐	☐

	Never			*Often*
53. baked bread, pastry, cake, etc	☐	☐	☐	☐
54. cooked a meal	☐	☐	☐	☐
55. walked while balancing an object on my head	☐	☐	☐	☐
56. used a wheelbarrow	☐	☐	☐	☐
57. used a crowbar (jemmy)	☐	☐	☐	☐
58. used a rope and pulley for lifting heavy things	☐	☐	☐	☐
59. mended a bicycle tube	☐	☐	☐	☐
60. used tools like a saw, screwdriver or hammer	☐	☐	☐	☐
61. charged a car battery	☐	☐	☐	☐

I. Myself as a scientist

Assume that you are grown up and work as a scientist. You are free to do research that you find important and interesting. Write some sentences about what you would like to do as a researcher and why.

I would like to . . . .

. . . .

. . . .

Because . . . .

. . . .

. . . .

. . . .

. . . .

J. How many books are there in your home?

There are usually about 40 books per metre of shelving. Do not include magazines.
(Please tick only one box.)

- None .... ☐
- 1-10 books .... ☐
- 11-50 books .... ☐
- 51-100 books .... ☐
- 101-250 books .... ☐
- 251-500 books .... ☐
- More than 500 books ...... ☐