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Maria Vetleseter Bøe,

Oslo, 15 December 2011
Abstract

This thesis is concerned with young people’s choices to study – or not study – science in secondary and tertiary education. The background for the research focus is the challenge of insufficient participation and female under-representation in many science, technology, engineering, and mathematics (STEM) fields. The main aim of the work has been to understand Norwegian students’ choices of post-compulsory science in an expectancy-value perspective, and relate their expectations and values to the sciences – physics in particular – to inform the discussion about improving post-compulsory participation in STEM. Three articles form the core of the thesis, and contribute to the main aim by addressing distinct research questions.

Article I reviews international research about young people’s relationships to and participation in STEM subjects and careers, through the lens of an expectancy-value model of achievement-related choices (Eccles et al., 1983). In addition, it draws on sociological theories of late modernity and identity which situate decision-making in a cultural context. The article examines how these frameworks are useful in explaining the decisions of young people – and females in particular – about participating in STEM, and proposes possible strategies for removing barriers to participation. The literature review establishes that young people’s interest in school science and mathematics is relatively low, and tends to decline as they progress through school. The subjects are often characterised as having transmissive pedagogy, and unengaging, de-contextualised content. However, students often show more interest in science topics, and regard science and mathematics as important in general but less so for them personally. They struggle to identify with STEM culture and with STEM professionals, and often find them ill-suited to their identity. Some students tend to choose post-compulsory science subjects for instrumental reasons: for example, to gain admission to a preferred university or to keep many options open. Science subjects are often perceived as particularly difficult, and this affects students’ expectation of success in these subjects, which tends to be lower than their expectation of success in other school subjects. The literature reveals gender differences in several aspects of young people’s relationship to science, aspects that are predicted by the Eccles et al. model to affect educational choices: Females are more likely than males to have low expectation of success and associate considerable costs with studying science and mathematics. Females are less likely than males to identify closely with science disciplines and professionals, and there are clear average differences in which science topics males and females are interested in.
Article II investigates the importance of various issues in 1,628 Norwegian upper secondary students’ choices of post-compulsory subject combinations: Natural science and mathematics (henceforth Science) or Languages, social science and economics (henceforth HumSoc). The study uses data from the Norwegian project “Lily” (see p. 13). Questionnaire items based on the Eccles et al. model of achievement-related choices are grouped into six construct measures by factor analysis: expectation of success, interest-enjoyment value, self-realisation value, fit to personal beliefs value, utility value for university admission, and relative cost. Interest-enjoyment and fit to personal beliefs were somewhat less important to Science students than to HumSoc students, especially to girls taking Science. Utility value for university admission was much more important to Science than to HumSoc students, and more important to Science girls than to Science boys. Keeping the costs low in terms of time and effort were much more important to HumSoc than to Science students. The findings indicate that students choose Science both for identity reasons – such as interests, self-realisation and fit to personal beliefs – and for strategic utility reasons. Some of the students, especially girls, appear to have placed more weight on utility than on their interests.

Article III uses questionnaire data from Norwegian physics students in upper secondary (N=585) and first-year tertiary (N=278) education to characterise the “physics choosers”. An expectancy-value perspective is adopted to describe the motivations and expectations behind the respondents’ physics choice. Secondary students were largely motivated by interests, self-realisation and/or the utility value of physics for university admission, and many of them planned to go into medicine (females in particular) or engineering (males in particular). Tertiary physics students appeared to be motivated by a passion for the subject, high interest and expectation of enjoyment, and many of them planned to go into research. Females expressed lower self-concepts of ability than males, and were more idealistically oriented concerning future job. However, gender differences were less prominent among tertiary than secondary students. The results indicate that tertiary physics students were well adapted to a physics discipline culture, where the subject in itself is emphasised. Moreover, the results suggest that upper secondary physics has a window of opportunity to introduce students to a wide range of career options in physics.

All the three articles discuss implications based on the presented material, and propose measures that may be taken if the goal is to improve post-compulsory participation in science. Among the recommendations are increased emphasis on context and socio-scientific issues in school science, and introducing students to a variety of STEM career
options that may be compatible with different identities. My co-authors and I recommend that students’ interest and enjoyment in science are supported, and that diverse interests beyond the subject itself must be met. The costs of science – in terms of difficulty and work load – may be perceived as less discouraging if more emphasis was placed on what science has to offer to the students. We argue for promoting a physics culture – in particular on the secondary level – that is more inclusive to broader motivations than interest alone, such as applications of physics in work related to global challenges and medicine. If they are put into action, these measures may lead to increased participation in post-compulsory science, and to more variation in the interests, priorities and practices of the science student pool. In particular, the results suggest that the gender balance in the physical sciences and technology may be ameliorated. In addition, special attention should be given to supporting females’ expectation of success in science and mathematics, and their identity formation in discipline cultures dominated by males and sometimes by masculine practices. Finally, we highlight the influential role of good science teachers, and stress that their working conditions must allow them to try innovative practices.
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Prologue

I would like to begin this thesis with a story. As this work is an attempt to understand young people’s science choices, it is tempting to tell you about my own choice. By now the story I tell myself is naturally filtered through a web of knowledge and experiences related to educational choices, and who knows what I would have written five or ten years ago. In any case, this is how I – right now – believe that I came to study physics.

I was a curious child. Not the constantly-asking-questions kind, I was the pondering kind. The kind with her nose in a heavy book, building maps out of blocks of information. I wanted things to fit together, to form a system. I still really do. The atlas was one of the first systems that fascinated me. A model of the world where all these things I heard and read about actually took place. To this day, every time I learn about something or someone in some place, a map pops up in my head with that something or someone on it. I cannot think about Shakespeare without seeing a flash of Britain with something stuck to the map a little to the left and up from London.

School science and mathematics never truly fascinated me in childhood school years. I was good at maths, and I liked doing it. But the great experiences, the discovery of maths as an elegant system, occurred much later. All the same, I remember my big brother Gunnar Jostein Bøe telling me, sometimes in lower secondary school, probably, that I should study mathematics. I said I didn’t want to become an economist. He said I didn’t have to, I could just do maths. And we left it at that. As for science, I suspect now that we covered mostly biology topics all through lower secondary school. I liked everything that had to do with the human body and its systems, but my interest for plants and animals never went beyond the compulsory teenage girl horse obsession. Sometime during my first upper secondary year, I came to realise that the bits I liked the most in science, were called physics. And again, I talked to my big brother, who had taken physics, mathematics and chemistry, and was now in engineering school. So there I was, taking post-compulsory mathematics, physics, and English. Good marks came easier in English, Norwegian, geography and history, than in physics and mathematics. I can still picture my first ever physics test, marked by the teacher. The test was about forces, and one of the tasks was to draw a free-body diagram for some object. Beside my feeble attempt, the teacher had written “this is a terrible construction!!” It really was. Luckily, it went uphill from there. When we started modern physics, I started to really enjoy it. The strange, sometimes counter-intuitive properties of the tiniest parts of matter, and of the unfathomably big universe fascinated me: the photoelectric effect, the
double-slit experiment, the Balmer series, background radiation, and neutron stars. Naturally then, I went to the Norwegian University of Science and Technology to study English.

As it turned out, I had not planned my English studies very well, and I ended up postponing it for six months while I took the compulsory pre-language study course in linguistics and phonetics. To fill a term’s worth of coursework, I also studied Examen Philosophicum\textsuperscript{1}, which everyone has to do before they graduate anyway. As the term progressed, I realised that what I loved about languages was not so much literature as it was their systems and regularities. My English-plan was crumbling.

In addition to Examen Philosophicum, students were at that time required to complete one of a range of introductory courses connected to various fields of study. I went for “Natural Sciences and World-View”. This course was not given at the same University campus as the linguistics, phonetics and Examen Philosophicum courses, but at a smaller, older campus which was then dedicated to studies in biology and chemistry. I can still remember, vividly, the feeling I had sitting in that auditorium, listening to chemistry professor Reidar Stølevik talking about the universe. It is a cheap cliché, but all the same: the mother ship was calling me home. I felt that I had found my place. So I signed up for physics and mathematics courses next term, which took place at yet another campus.

During the next couple of years the sense of belonging increased. I built a Bachelor’s degree in physics and mathematics, formed friendships for life, and learned how to play bridge (though not very well). I never planned very far ahead. I knew I was going to pursue a Master’s degree in physics or mathematics, and along the way I basically chose the courses that appeared to be intriguing. My friends definitely had an impact, as some of them were a year above me and could tell me what I needed to know about the courses. If I as a researcher were to interpret my own story, I would say I was largely driven by interest and attainment. I admit that I really wanted to be someone who did well in science and mathematics. I tended to be seen as ‘the brains’ in my class in school, and that sort of grew on me. My all-time best University result was achieved in an algebra course where the professor told me midway that I would fail if I did not start taking it seriously. As I was not going to have professors believing I would fail, I got to work. He provoked me into success,

\textsuperscript{1} Examen Philosophicum is an introductory course in philosophy and theory of science that must be passed to receive a University degree in Norway.
so to speak. Following this revenge on my professor, I thought about pursuing algebra, though only for about a week. My heart was set on theoretical physics.

I was – and still am – very taken in by astrophysics, particle physics, and quantum field theory. These fields describe phenomena that in some ways appear truly alien to the world we live in, and at the same time they are basic cornerstones of our existence, involved in everything and everywhere. They are fundamental, yet strange. So strange that one of the smallest particles is named Strange. I am one of those who love that mathematics and various forms of representation are essential in these branches of physics. Sometimes physics is written in mathematics in an enormous, messy and complicated way, as is the case with renormalisation. Other times it is beautifully elegant, like in Feynman-diagrams.

As far as I can remember, I have never had a real, long-lasting ambition of having a specific occupation. At some point, I realised that my educational choices would, ultimately, limit my options. This realisation came embarrassingly late, well into the Master’s level of my physics studies. So I decided to get certified as a teacher, to always have teaching as an option. I figured I’d like teaching because I liked tutoring other students. Had I given some more thought to what I wanted to work with after my Master’s, I believe I might have chosen differently. Passion for physics and the satisfaction of understanding – of seeing the system – was enough for a little, pondering girl, and for a bigger, pondering student. But the adult citizen who graduated from University needed more. I am still not sure what – a deeper purpose, clearer relevance for society? Possibly. In any case, I decided to pursue a PhD in science education, and go where that would take me. So far it has taken me here. To the thesis you are about to read (if you’re still interested).
1 Introduction

1.1 The thesis

This thesis concerns young people’s choices to participate or not in post-compulsory science, technology, engineering, and mathematics (STEM). All empirical work deals with Norwegian data, collected from respondents in secondary and tertiary education in Norway. The work, therefore, consequently has a specific focus on a Norwegian cultural and educational setting. However, most issues dealt with in the three articles and in the dissertation are relevant to a broader international audience.

I start by stating my overarching aim and research questions in section 1.2. The section goes on to introduce the three articles that form the core of this thesis, and argue for how they coherently address the primary aim. Section 1.3 briefly places the work in the landscape of research on young people’s STEM-related choices, followed by section 1.4 on the theoretical perspectives I have employed. Chapter 2 is concerned with methods and methodology. I will give an account of the methods I have chosen, and highlight some methodological considerations in respect to these choices. Section 2.1 introduces the project “Lily”\(^2\) that this research was part of, and in sections 2.2, 2.3, and 2.4 I give an account of the choice of design and of the data collection. Section 2.5 discusses validity issues for the work presented in this thesis, and section 2.6 points to some limitations of the work. The results of my work are given in the three articles, and I will only very briefly sum up the main findings in chapter 3.

In chapter 4 I will present some reflections that are broader than what can typically be done in the journal article format. The discussion will have the articles as its starting point, but some of the reflections move beyond what my findings can answer.

1.2 Overarching aim and research questions

The primary aim of the work presented in this thesis is

- to understand Norwegian students’ choices of post-compulsory science in an expectancy-value perspective, and relate their expectations and values to the

Each article included in the thesis addresses separate research questions. For every research question, the answers are discussed in terms of implications for improved participation in STEM. As Article I is a review and not an empirical research report, its research questions are more thematic in nature.

**Article I**

Published as:


Research questions:

- How can international research about young people’s relationships to and participation in STEM subjects be understood in terms of the Eccles et al. expectancy-value model of achievement-related choices?
- How can sociological theories on late modernity and identity improve our understanding of the STEM-related choices made by young people in late-modern societies?

**Article II**

Published as:


Research question:

- To what extent were various expectancy-value factors important for Norwegian upper secondary students’ choices to study – or not study – post-compulsory science?

**Article III**

Submitted to *Science Education* as
Love it or leave it.
Norwegian students’ motivations and expectations for post-compulsory physics.

Research questions:

- What characterises the motivations and expectations of Norwegian students who have chosen physics in secondary or tertiary education?
- What characterises the educational and occupational aspirations of Norwegian students who have chosen physics in secondary or tertiary education?
- How do these characterisations relate to descriptions of physics culture?

The three articles and how they collectively address the overarching aim

Article I is a review article synthesising research literature and theoretical perspectives to address issues of participation in STEM. The article views research about young people’s relationships to, and participation in, STEM subjects and careers through a lens of an expectancy-value model of achievement-related choices. It draws on sociological theories of late modernity and identity to situate decision-making in a cultural context. The article demonstrates how these frameworks are useful tools when trying to understand young people’s decisions about participating in STEM.

The article sets the scene for this thesis in several ways. First, it establishes the nature and scope of STEM participation problems through an examination of available statistics and reports from a variety of countries and institutions. Second, it presents five reasons for why participation in STEM should be improved, and it establishes gender as an important factor in studies of STEM participation issues. Third, the article presents the Eccles et al. expectancy-value model of achievement-related choices (Eccles et al., 1983), and discusses its strengths and weaknesses as a framework for studying STEM-related choices. It also presents perspectives from sociological theories of late modernity and identity, and demonstrates how these can deepen the understanding of how aspects of the Eccles et al. model influence the STEM-related choices of late-modern young people. The article, therefore, provides a thorough account of the theoretical frameworks used in Articles II and III, and thus informs the entire thesis. Fourth, the article includes a literature review of a large amount of research in science (and mathematics) education specifically on young people’s STEM-related choices, and more generally on aspects of their relationships to
STEM that are likely to influence such choices. This review, therefore, gives a description of the research field Articles II and III are part of.

*Article II* investigates the importance of various issues in 1,628 Norwegian upper secondary students’ choices of post-compulsory subject combinations: Natural science and mathematics (henceforth Science) or Languages, social science and economics (henceforth HumSoc). The study uses data from the Norwegian project “Lily” (see p. 13). Questionnaire items based on the Eccles et al. model of achievement-related choices are grouped into six constructs by factor analysis: expectation of success, interest-enjoyment value, self-realisation value, fit to personal beliefs value, utility value for university admission, and relative cost. Scores on these constructs for girls and boys who chose Science and HumSoc – and differences between them – are examined in the light of the theoretical perspectives presented in Article I, and implications for participation in post-compulsory STEM education are discussed.

The article demonstrates how the Eccles et al. model can be used in a retrospective approach to study young people’s educational choices. It presents construct measures created from a questionnaire based on the theoretical frameworks presented in Article I, and discusses strengths and weaknesses of the instrument. The instrument can be used and developed further by other researchers. As the choice examined was of a combination of subjects – a programme area in the official term of the Norwegian upper secondary school system (vilbli.no, 2010) – few subject specific issues are discussed in Article I.

*Article III* characterises secondary and tertiary physics students in terms of what inspired and motivated their choices, their expectations for the courses/study, what they valued in a future job, and what kind of a job they wanted in the future. The results are interpreted in the light of the theoretical perspectives accounted for in Article I, and discussed against descriptions in the research literature of physics as a discipline culture. The article goes on to discuss implications for improved participation in physics. In contrast to Articles I and II, Article III focuses specifically on one STEM discipline: physics. By focusing on one discipline, the article gives room for discussing participation in the light of characteristics that are specific to the one subject and its culture, and target a specific audience more directly. By choosing physics as this one discipline, the article looks specifically at one of the STEM fields were participation problems are at their most pronounced, in terms of under-enrolment, gender imbalance, and shortage of professionals.
Focusing on physics also gave my co-author Ellen Henriksen and me the possibility to write about the subject in which we have our own backgrounds.

Separately, the articles answer distinct research questions. As a whole, their contributions respond to the overarching aim stated on p. 1. Article I lays the groundwork by establishing expectancy-value perspectives as a useful tool for understanding young people’s educational choices, and for interpreting what young people’s relationship to STEM – as documented in the research literature – can tell us about their participation in STEM. Article II employs the expectancy-value perspectives on empirical data from Norwegian upper secondary students, and investigates the importance of various expectancy-value factors for their choices to study or not study post-compulsory science. These expectancy-value factors are discussed in terms of how they can be met in the school sciences and STEM studies and careers, to promote post-compulsory participation. Article III employs the expectancy-value perspectives to understand Norwegian students’ choices of secondary and tertiary physics specifically. It responds to the documentation in Article I that physics is one of the STEM disciplines where participation problems are most pronounced, and the motivations, expectations and plans that characterise secondary and tertiary physics students are discussed against descriptions of a physics discipline culture. The article points to ways forward for encouraging more students – more females in particular – to study physics. Collectively, the articles, thus, contribute to an understanding of Norwegian students’ choices of post-compulsory science in an expectancy-value perspective, and relate their expectations and values to the sciences – physics in particular – to inform the discussion about improving post-compulsory participation in STEM.

1.3 Placing my piece in the puzzle

The work presented in this thesis adds to a considerable body of studies concerning young people’s STEM-related choices. As much of this literature is included in the review in Article I, I will not give an extensive review here. Instead, this section will only briefly refer to some of the literature, specifically mentioning a few studies that have come to my attention after Article I was submitted. Finally, I will place the work in this thesis in the total picture of the research field.

Broad studies of young people’s aspirations for and choices of STEM studies and careers include the Australian “Choosing science” study (Lyons & Quinn, 2010), “Staying in Science” in New Zealand (Hipkins & Bolstad, 2006), and the Future Track Survey
(Purcell et al., 2008) and STEM careers awareness timelines (Hutchinson, Stagg, & Bentley, 2009) in the UK, and the ASPIRES project in England (DeWitt, Osborne, et al., 2011). In the US, much has been published from the Michigan Study of Adolescent Life Transitions (see e.g. Eccles, Vida, & Barber, 2004). Other examples of US studies are the Childhood and Beyond longitudinal study (Denissen, Zarrett, & Eccles, 2007), Aschbacher, Li, and Roth’s (2010) study of high school students’ participation in science, engineering, or medicine, and Maltese and Tai’s (2011) study of students’ choices of college majors in STEM. In Norway, the FUN study about students’ attitudes to and choices of physics (Angell, Guttersrud, Henriksen, & Isnes, 2004) and Kjærnsli and Lie’s (2011) study of career aspirations based on PISA 2006 should be mentioned, in addition to the Lily study (Henriksen, Jensen, & Sjaastad, 2011; Schreiner, Henriksen, Sjaastad, Jensen, & Løken, 2010).

Much work has been done in this area by Jacquelynne Eccles and colleagues. For the most part, they have studied how expectation of success and subjective task values predict educational and occupational choices. These investigations include studies of college enrolment in mathematics and English (Eccles et al., 2004), high school course enrolment in mathematics and science (Simpkins, Davis-Kean, & Eccles, 2006), and studies of gender differences in STEM choices (Eccles, 2007; Nagy et al., 2008). Most studies of participation in STEM include an investigation along gender lines, since female underrepresentation is such a pronounced issue (see article I). A specific gender focus can be found in, for example, Shapka, Domene, and Keating’s (2008) study of career aspirations among young people in Canada, in Lapan, Shaughnessy, and Boggs’ study of college majors in science and mathematics in the US (1996), in Quinn and Lyons’ (2011) exploration of Australian high school students’ intentions to study university science courses, and in the investigation of physics career aspirations among high school students in the US done by Hazari, Sonnert, Sadler, and Shanahan (2010). Hazari and colleagues also used identity as an analytical tool in their study, as has been done by various other researchers. These include Taconis and Kessels (2009), who found that Dutch and German students chose school subjects by comparing themselves to the typical physics, biology, language, or economics students, and the longitudinal study of Danish students’ choices to study engineering done by Holmegaard, Ulriksen, and Madsen (2010), as well as the ASPIRES project (DeWitt, Osborne, et al., 2011) mentioned above.
Identity connected to interest has been central in many discussions about participation in science based on the ROSE project, where 15 year-old students in many countries answered a questionnaire about their interests in and attitudes towards science and technology (see e.g. Oskarsson & Karlsson, 2011; Schreiner, 2008; Schreiner & Sjøberg, 2007). Generally, the interest dimension is represented in a wide range of studies (Archer et al., 2010; Henriksen et al., 2011; Hipkins & Bolstad, 2006; Lindahl, 2003; Maltese & Tai, 2011; Rødseth & Bungum, 2010; Ulriksen, 2010). Investigations of the influence of role models for STEM choice are found in, for example, Aschbacher et al. (2010), Sjaastad (2011), and Hazari et al. (2010), whereas specific discussions about the impact of efficacy beliefs are seen in, for example, Bandura, Barbaranelli, Caprara, and Pastorelli (2001) and Lapan et al. (1996).

Many studies focus on background parameters such as socio-economic status and ethnicity and their relationship to students’ STEM choices. Lyons (2006) studied how the cultural and social capital of the family influenced students’ participation in post-compulsory physics and chemistry. DeWitt, Osborne, et al. (2011) connected children’s aspirations in science to their ethnicity, cultural capital, and gender. Based on the same ASPIRES project, DeWitt, Archer, et al. (2011) discussed aspirations and progression amongst minority ethnic students specifically.

In the picture painted above, the work in this thesis can be placed among studies that focus on the individuals (or groups of individuals) more than on social and cultural background factors. The research is concerned with young people’s own perceptions of what was important for the choice they have made, and of what would be important in future educational and/or occupational choices. Most of the factors that are discussed can be conceptualised as expectations and subjective values related to various educational options (e.g. expectation of success, interest and identity). The work, therefore, has much in common with studies that concern interests and identity. The retrospective approach and the measuring of students’ perceptions of what was and would be important, separates this study from investigations of how well certain factors predict future participation in STEM. Because we have measured the students’ perceptions of the importance of, for example, personal interests and self-realisation, the perspectives on late modernity offer valuable insight into why students placed much importance on such subjective values. In this sense, the culture the students live in is implemented and discussed indirectly. Nevertheless, the influence of students’ socio-economic background, cultural capital, or ethnicity, has not
been studied directly. However, according to the Eccles et al. model (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000), such background factors affect young people’s choices indirectly. A student’s family may portray various occupations as more or less suitable for the student in ways that are linked to their cultural capital or socio-economic status. The student’s perception of what their family expects of them forms their image of themselves and, in turn, their expectation of success and subjective values connected to, for example, occupations. It is, therefore, likely that the family background of the Lily respondents explains parts of the variance in their choices. However, Kjærnsli and Lie (2011) found that family background explained very little of the variance compared to psychological factors such as interest. Investigations of such background factors have not been the focus of my work.

1.4 Reflections about theoretical perspectives

The very notion of choosing which theoretical perspectives that would inform my work has been challenging. With a background in physics, I entered science education from a paradigm where the validity of a theory or model is judged by its ability to predict experimental results, and by its coherence with other models that have proven resilient to falsification. Research in social science – for example in science education – happens in a far more complex landscape of theories and models, where choices of theoretical frameworks made by the researcher to a larger extent affect the results.

Throughout this thesis, I have used the same theoretical perspectives in different phases of the study: in the questionnaire development, in the data analyses, and in the interpretation and discussion of the results. I have brought together two sets of perspectives: The Eccles et al. expectancy-value model of achievement-related choices (Eccles et al., 1983), and sociological theories on late modernity and identity development. The combination of the Eccles et al. model and the sociological perspectives on late modernity as tools for understanding young people’s STEM-related choices is, as far as I am aware, new. The Eccles et al. model says, in short, that educational choices are most directly affected by whether students expect to succeed with, for example, a physics course, and by the value the physics course has for the students. We can picture young people asking themselves: “Can I do this?”, on the one hand, and “What’s in it for me?”, on the other.

According to the model, young people’s answers to these questions are influenced by their identity, which is in turn formed by their social and cultural surroundings and
experiences. Therefore, I draw on sociological theories on late modernity and identity development, which place young people’s decision-making in a cultural context. Both sets of perspectives and examples of how they can inform studies of young people’s STEM-related choices are presented in Article I (Bøe, Henriksen, Lyons, & Schreiner, 2011), and no further description will be given here. Article I also presents an argument as to why the Eccles et al. model was chosen over other possible approaches to educational choices, and gives an account of the model’s strengths and potential weaknesses when used to study choices in STEM. The model is inclusive in the sense that many of its constructs overlap with concepts from other motivational theories (see Eccles & Wigfield, 2002), such as Bandura’s (1997) theory of self-efficacy, Ryan and Deci’s (2000) theory of intrinsic and extrinsic motivation, and Hidi and Renninger’s (2006) and Krapp’s (2002, 2005) theory of interest.

However, I could have chosen to focus solely on self-efficacy as described by Bandura (1997), or on the central element of interest (Krapp & Prenzel, 2011), both of which might have led to different interpretations and discussions. I believe that choosing a model focusing on both expectation of success (self-efficacy) and subjective values such as interest and utility, enabled me to study the importance of several factors that all influence young people’s choices of STEM and describe a larger part of the picture in my results. Consequently, it was not feasible to discuss all the factors in such detail and depth that would be possible if, for example, I had chosen to look at interest alone. However, an expectancy-value approach enabled the focus on identity and self-realisation that is seen in this work. This focus was in part motivated by claims that more attention should be given to the role that identity development plays in young people’s orientations to school science (Aikenhead, 2006; Osborne, Simon, & Tytler, 2009; Schreiner, 2006).

Exploring the different influences on young men and women is a classic element of studies in science and mathematics education (see e.g. Eccles, 2007; Jenkins, 2006; Kjærnsli, Lie, Olsen, & Roe, 2007; OECD, 2007; Osborne et al., 2009; Scantlebury & Baker, 2007; Schreiner, 2006; Sørensen, 2007), with much research addressing gender issues and approaches to gender equity in science and mathematics education (for reviews see Hutchinson et al., 2009; Kenway & Gough, 1998; Spelke, 2005). As presented in Article I, both the Eccles et al. model and the sociological theories on late modernity specifically address gender, and I employ no specific gender framework in this thesis.
This thesis uses a range of terms for theoretical constructs. Many of them have a substantial amount of scholarly work dedicated to them in terms of how they are defined and what properties they describe among young people. I refer, for example, to ‘interest’, ‘identity’, and ‘self-concept of ability’ or ‘expectation of success’. As all of these terms are conceptualised in the theoretical perspectives I have employed, they will not be defined here. Nevertheless, it is worth mentioning that the constructs in the Eccles et al. model are linked to other motivational theories in a broad and quite inclusive manner. For example, Eccles and Wigfield (2002, p. 120) stated:

“Intrinsic value is the enjoyment the individual gets from performing the activity or the subjective interest the individual has in the subject. This component of value is similar to the construct of intrinsic motivation as defined by Harter (1981), and by Deci and his colleagues (e.g., Deci & Ryan 1985), and to the constructs of interest and flow as defined by Csikszentmihalyi (1988), Renninger (Renninger et al. 1992), and Schiefele (1999).”

This quote may give the impression that the model is vague or an attempt to reconcile many approaches to motivational behaviour. However, the described conceptualisation of interest-enjoyment value was well argued for by Eccles and Wigfield (2002). I would argue that the link to various other motivational theorists reflects the nature of educational choice: complex and multifaceted, and approachable from different angles. The research questions one seeks to answer should guide the operationalization of, for example, interest-enjoyment. Because this work studied interest-enjoyment together with many other aspects, the construct has not been either measured or discussed on a detailed level. In my opinion, the construct measure Interest-enjoyment developed in Article II (TABLE 3) has both a personal and situational interest component, and thus tried to integrate rather than distinguish between the two. Much work on interest has been done in science education, as described by Krapp and Prenzel (2011), and future research may approach more in-depth studies of this aspect of STEM choice in several ways.

I have consistently used the term ‘gender’ and not ‘sex’ when referring to biological sex, and ‘gender role’ when specifically referring to social sex. I am aware that there is great controversy concerning these terms and their use, and that some prefer to use ‘sex’ for biological sex and ‘gender’ or ‘sex role’ for social sex. However, I decided to use terms that
corresponded to those used by Eccles and colleagues in the publications that comprise most of my theoretical perspectives.
2 Methods and methodology

2.1 Lily

The Lily study (Henriksen et al., 2011) is a quantitative survey about the educational choices of around 14,000 Norwegian students in secondary and tertiary education. It aims to contribute to increased participation in STEM by producing generalizable knowledge about why students do or do not choose science-related subjects and studies. The results presented in Articles II and III came from data from two basic sources: from a sample of Year 12 upper secondary students undertaking Specialisation in General Studies, and from the population of students attending their first year in a higher education physics study or at the Norwegian School of Economics (NSEC) in 2008 (see article III). The upper secondary students responded to a questionnaire early in Year 12 and had recently chosen their programme area for the last two years of upper secondary school, Year 12 and 13 (FIGURE 1). This choice is critical as the Science programme area is a requirement for higher education STEM studies (Norwegian Ministry of Education and Research, 2010). The higher education students responded to a questionnaire during their first week of higher education.

Norwegian students generally spend three years in upper secondary school. Students who choose General Studies and Specialisation to general studies (FIGURE 1) all follow the same compulsory courses the first upper secondary year (Year 11), but choose one of three programme areas for the next two years. Roughly 40% of the age cohort in 2008 were in the pre-academic Specialisation to general studies programme (NDET, 2009). According to the Norwegian Directorate for Education and Training (NDET) (2009), 40% of students in Year 12 in 2008 chose Natural science and mathematics (henceforth Science), 53% chose Languages, social science and economics (henceforth HumSoc), and 5% chose Arts, crafts and design (these students were outside the target group and not included in this study). Girls accounted for 46% of the Science students and as much as 60% of the HumSoc students (Statistics Norway, personal communication, June 29, 2009).

3 There were generally three options available when the data were collected in 2008, though in 2011 some schools also offer international baccalaureate programmes.
FIGURE 1: Norwegian upper secondary school system

Note. Possible paths from Year 11 General Studies (Vocational upper secondary training is not included in the figure). Students in paths illustrated by grey, dotted lines were outside the target group.

Many countries have reported that a decreasing proportion of upper secondary students choose science and mathematics, for example Australia (Lyons & Quinn, 2010), the UK (Institute of Physics, 2010), New Zealand (Hipkins & Bolstad, 2005) and India (Garg & Gupta, 2003). In Norway, however, there has been a slight upturn in the number of Norwegian students finishing upper secondary school with a comprehensive grounding in science and mathematics (Hægeland, Kirkebøen, & Skogstrøm, 2007). Nevertheless, this upturn is not thought to be sufficient to meet the projected need for future STEM professionals in Norway (MER, 2010). Many researchers have suggested that young people, females in particular, are reluctant to participate in the physical sciences and engineering due to a perceived lack of relevance and fit to personal values (Eccles, 2007; Kozoll & Osborne, 2004; Osborne, Simon, & Collins, 2003; Ramberg, 2006; Schreiner & Sjøberg, 2007; Taconis & Kessels, 2009). The Lily study draws on this perspective where an expectancy-value model of educational choices is employed to study young people’s choices in secondary education.
2.2 **Choice of design**

In the work presented in this thesis, a clear aim has been to produce generalizable knowledge about students’ choices to participate – or not participate – in post-compulsory science education. My colleagues and I, therefore, chose to conduct a survey investigation, which is a simple and straightforward approach to studying the students’ responses regarding attitudes, priorities and values, in a way that creates generalizable information. Other strengths of such a quantitative approach are that large amounts of data can be collected in a relatively short time, and that the procedure ensures anonymity. Anonymity allows the respondents to be honest in a way that some may find difficult when they are face to face with an interviewer (Robson, 2002). Still, there is a risk that some might respond in a way that describes them as they would like to be, or the way they believe the researchers would like them to be. As in any self-report approach the data are affected by characteristics of the respondents, such as memories, knowledge, personality and experience. Questions may be misunderstood or the task of answering not taken seriously (Robson, 2002). Although the coding and ‘data cleaning’ procedures (see the section Reliability) take care of obvious non-serious answers, some may remain undetected. The largest limitation of a survey approach is that a questionnaire can only state which answers are given, which boxes have been ticked, it cannot tell us what exactly was meant by each respondent for each ticked box. See the section Construct validity for more on this matter.

The choice of a large scale quantitative survey is a choice of the general rather than the particular, of averages and majorities rather than individuals and marginal groups. I have chosen to study average scores for large groups of respondents. I have divided respondents into pre-defined groups based on their choices of subjects and on their gender, and studied mean score differences between such groups. I have chosen not to study individual differences among members of the same group. However, such differences can be studied by different quantitative approaches to the same data material, or different qualitative approaches. Due to the quantitative design of the study, the implications that are discussed in this thesis are based on results that concern averages, means and majorities. Consequently, it makes little sense to use the results to categorise an individual or suggest how this individual may be persuaded to choose STEM. The generalisations my colleagues and I make in the articles are from averages in the sample to averages in the population, not to individuals in the population (or in the sample for that matter). Though this point is highly logical, I believe it is important to make.
There was a small qualitative component in the design of the Lily study. Two focus groups interviews were conducted, one with upper secondary respondents and one with respondents in their first year of higher education STEM studies. Beyond these focus groups the study was not piloted. During the data analyses, therefore, some items were not pursued further and others removed from factor analyses because they appeared not to have worked as intended. This concerns items with severely skewed responses, large missing rates, or unclear factor loading patterns.

### 2.3 Questionnaire development

The research project Lily has four different questionnaires all together. Three of them were used to collect data that were used in the work presented in this thesis. One collected responses from Year 12 students in upper secondary school, specialisation in general studies, one from first year students in STEM studies in universities and university colleges, and one from first year students in non-STEM studies, for example, students in the Norwegian School of Economics (NSEC). The three questionnaires were developed alongside each other, in cooperation with the rest of the research group, and are largely similar (see Appendices). We tried to keep as many questions and items as possible identical, in order to be able to compare results. All questionnaires are in part based on the Eccles et al. model of achievement-related choices, and on previous research in science education, especially studies concerning the importance of identity. The study was reported to the Norwegian Social Science Data Services (NSD). The questionnaires were put through several tests to heighten the quality. We conducted two focus group interviews during the spring 2008. In the first one we tested the questionnaire for higher education STEM students, with a small group of science students at the University of Oslo as participants. In the second one we tested the upper secondary questionnaire, with five students who were about to finish their first year of upper secondary school in Oslo. These focus group interviews were conducted to help develop the questionnaires and strengthen construct validity. The participants filled in the upper secondary and higher education STEM questionnaires, respectively, followed by a group discussion about various aspects of the questionnaire such as interpretation, length and format, difficulty of answering and general impression. The participants’ understanding and interpretation of the items were discussed. Their responses were used to revise the questionnaire. The participants took a little too long to fill out the questionnaires, and some items had to be cut. Some were also cut for being repetitive and

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annoying, and a few were added so that everyone could find suitable alternatives. The order of the items was adjusted, and long questions were broken up so that the questionnaire should be less monotonous. I also asked a few teachers, colleagues, four secondary school advisors and consultants, and some friends and siblings for their opinion about the upper secondary questionnaire. This gave valuable input in the questionnaire development.

2.4 Data collection

This thesis presents results from the Lily study based on both upper secondary and tertiary education data. However, I have been responsible for the questionnaire development and data collection on the upper secondary level. The following section, therefore, accounts for the upper secondary data collection. Other members of our research group have been responsible for the tertiary education data collection, and more on this process can be found in Schreiner et al. (2010) and Henriksen et al. (2011).

The sampling for the upper secondary data collection was done in March 2008. For practicality reasons, I did cluster sampling (see e.g. Kleven, 2002; Robson, 2002) and sampled schools instead of students. The target schools were Norwegian upper secondary schools which offered specialization in general studies in VG2 in 2008/2009, with Science as one programme area option. I used Pedlex Norsk Skoleinformasjon\(^5\) to identify the schools and to select those which offered specialization in general studies. 90 of these schools were randomly selected to participate. After invitations were sent out, however, it became clear that 17 of the sampled schools were ineligible for participation. Most of these schools were listed in Pedlex Norsk Skoleinformasjon with incorrect or insufficient information about which programme areas they offered, two schools had a curriculum and structure which made them incompatible with the research aims, and two schools were closed down during the summer between the sampling and the data collection. This meant that 73 eligible schools were invited to participate.

Invitations to participate were sent to the selected schools’ headmasters by post, including a reply coupon and prepaid envelope. Schools that failed to reply within the set deadline were followed up first by e-mail and then by telephone. Despite my best efforts, thirty schools declined the offer to participate, and one school failed to carry out the survey even after agreeing to do so. Hence, a total of 42 of the 73 schools participated in the study, which gives us a school response rate of 58%. To avoid an overrepresentation of students

\(^5\) [http://ped.lex.no/4DACTION/WA_Adresse](http://ped.lex.no/4DACTION/WA_Adresse)
from large schools, I decided to not include all students in schools with more than two parallel groups (classes) in VG2 SGS. For schools with three or more parallels, two groups were randomly selected to participate. 6 Approximately 85% of all students in groups that agreed to participate responded. Some contact persons in the schools have reported that students were absent on the day the survey was conducted, but other than that we do not know why some students did not participate.

Each respondent filled in a questionnaire booklet, and the data have therefore been coded from paper to statistical software. In cooperation with the Lily research group I created a code manual and prepared a Microsoft excel workbook for the data to be filled in to. The actual coding of the responses was done by five people; four university students hired to do the job and myself. All hired coders were given introductory training by myself or another member of the research group. Roughly 11% of all filled-in questionnaires were coded twice, by two different people.

The questionnaire used a 4-point scale with no neutral mid-category to prevent respondents using a mid-category response as an "I don’t know"- or "does not apply"-response (Kulas, Stachowski, & Haynes, 2008), and force them to express an opinion. On the front page of the questionnaire, respondents were instructed to leave the space blank if they found that none of the alternatives fitted, or if they did not understand the question. The mid-categories 2 and 3 were not named, thereby encouraging respondents to interpret the distance between the boxes as equal (Cummins & Gullone, 2000).

The complete cleaned secondary data file has 1690 respondents. 1628 (96%) of these were from respondents in the Science and HumSoc programme areas. The remaining 62 respondents, who checked “Arts, Crafts and Design” or “other” on the question about programme area, were not included in the analyses in article II. However, six students who had missing responses or checked the “other” box for programme area were included in article III, because they attended Level 1 physics. Three of these students attended a technology programme area specific to one school.

Due to the low response rate of 58%, the representativity of the sample is addressed below by comparing the distribution according to gender and programme area (TABLE 1) and Norwegian regions (TABLE 2).

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6 One school was allowed to include three groups in the study. This school had divided the students into groups by a specific subject choice, and selecting only two of them would have caused systematic bias in the data.
TABLE 1: Distribution according to programme area and gender

<table>
<thead>
<tr>
<th>Group</th>
<th>Respondents (percentage)</th>
<th>Population*(percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>21.1</td>
<td>19.8</td>
</tr>
<tr>
<td>Boys</td>
<td>24.1</td>
<td>23.1</td>
</tr>
<tr>
<td>HumSoc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>33.8</td>
<td>34.2</td>
</tr>
<tr>
<td>Boys</td>
<td>20.9</td>
<td>22.9</td>
</tr>
</tbody>
</table>

*(Statistics Norway, personal communication, June 29, 2009)*

TABLE 2: Distribution according to Norwegian regions

<table>
<thead>
<tr>
<th>Region of Norway</th>
<th>Respondents (percentage)</th>
<th>Population*(percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>11.6</td>
<td>8.6</td>
</tr>
<tr>
<td>Middle</td>
<td>9.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Eastern</td>
<td>46.3</td>
<td>50.6</td>
</tr>
<tr>
<td>Western</td>
<td>19.2</td>
<td>26.5</td>
</tr>
<tr>
<td>Southern*</td>
<td>13.4</td>
<td>5.8</td>
</tr>
</tbody>
</table>

*(Statistics Norway, personal communication, July 13, 2010)*

TABLE 1 shows that the distributions according to gender and programme area in the sample are relatively similar to those found in the population. There are some differences in the distribution according to regions of Norway (TABLE 2), but it is unlikely that geographical differences should affect the results, and I have chosen not to pursue this aspect further, for example, by weighing data to better reflect the population. I will return to the representativity of the sample in the section Generalizability.

2.5 Validity

In short, *validity* refers to the approximate truth of an inference (Shadish, Cook, & Campbell, 2002). Robson (2002) distinguished between four types of validity: *reliability*.

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7 The underrepresentation of Southern Norway and overrepresentation of Western Norway come from under- and overrepresentation of the counties Vest-Agder and Rogaland, respectively. These are neighbouring counties on each side of the region border.
refers to consistency of measurement, *internal validity* to grounds for interpretation of causality, *construct validity* to whether we measure what we believe that we measure, and *generalizability* to the likelihood of the findings being true for other persons, settings or times than those actually participating in the study. In this section I address these four types of validity in terms of the results presented in this thesis, and discuss the use of the Likert scale.

**Reliability**

Reliability concerns the consistency of a measurement. A reliable instrument measures the same aspect in a consistent way for every respondent that participates. Reliability is a property of the data. Threats to reliability are participant error and bias, and observer error and bias (Robson, 2002). Participant error refers to more or less random variation in a respondent’s answers based on external factors such as tiredness or illness. In samples as large as the ones we had in Lily, such participant errors will, most likely, be distributed randomly and evened out to pose little threat to validity of results. Participant bias occurs when a respondent’s answers are influenced by, for example, a wish to please the researchers or the teachers, or by respondents’ reluctance to admit certain things about themselves. Such effects are hard to separate from ‘true’ variation. One way to reduce participant bias is to ensure the respondents about the anonymity of their answers. Respondents in the upper secondary Lily study were not asked to identify themselves in any way (by name or other contact information). The teachers who administered the data collection in their classrooms were instructed to let the respondents themselves put their filled in questionnaire in an envelope, to stress that no one at their school would read their answers.

Another argument that participant bias is less of a threat in this study is that the questions we have asked are not particularly sensitive. The tertiary Lily questionnaire differed from the secondary questionnaire in that respondents were able to voluntarily give their contact information. Another possible source of participant bias is respondents sabotaging the data collection, for example, by giving joke responses or drawing pictures of x’es on the questionnaire sheet. Obvious sabotage responses were detected and coded as missing values.

Observer error in this study translates to the degree of error when the responses were coded from paper booklets to statistical software. To detect such errors, a certain percentage
of both secondary and tertiary responses were coded twice, by two different people. Among the secondary responses, roughly 11% of all filled-in questionnaires were coded twice. Reliability checks revealed 1.2 typing error per booklet on average. Among the whole tertiary sample of 9199 responses – in which the tertiary physics and NHH students were included – 176 were coded twice, and 0.8 typing errors per booklet was found. As each booklet’s information was coded into more than 160 spreadsheet columns, 1.2 and 0.8 errors per booklet were found to be satisfactory. Observer bias does not pose a great threat to reliability in a large scale quantitative study like Lily, especially not when most responses were given to closed Likert type questions.

As for internal consistency, all construct measures used in articles II and III were tested by use of Cronbach’s alpha, as reported in the articles. The widely accepted cut-off point of .7 for attitudinal measures (Gable & Wolf, 1993) was employed as a guide. The unidimensionality of construct measures was examined by studying strength and dispersion of inter-item correlations and by evaluating the stability of the measures when they were subjected to a factor analysis only including the items in each measure. In article III we reported scores on a few single items. Single items are generally less reliable than construct measures. On the other hand, they are often easier to interpret, given that they are specific and not designed to measure a latent trait. We have strove to be careful with inferences based on single-item results. For example, we have tried to use them together with other single-item results, as well as with construct measures or open-ended responses in order to strengthen the validity of the inferences.

Internal validity

As for internal validity, the Lily study did not test hypotheses or evaluate the effect of some treatment, and no direct inference of causality has been made. However, there is possibly an element of causality in the assumption that, for example, secondary respondents who chose science as their programme area and expressed that interest-enjoyment was important in their choice, chose science because they expected to find interest and enjoyment in those subjects. There were clear correlations between what the students expressed as important for their choice and their expectations for the programme area they had chosen, but a correlation does not imply causality. I have, therefore, made inferences concerning, for example, the importance of various factors for students’ choice of programme area, and not about a factor’s predictive power for choice of programme area. However, there is theoretical support in the Eccles et al. model for inferring a certain level
of causality. According to the model (Eccles et al., 1983; Eccles & Wigfield, 2002) students’ perception of, for example, a school subject, and their previous experiences related to this subject, form the subjective value a school subject has for this student. What students expect a subject to be like, therefore, affects the value the subject has for them, which in the model is causally linked to their choice to take or not take the subject.

Construct validity

There will always be some uncertainty as to whether what has been measured is correctly inferred by the researchers. The results presented in this thesis have been subjected to interpretation several times. For every questionnaire item, each respondent read and interpreted the question and the scale labels and decided which box to tick. I, the researcher, have my interpretation of the question, the scale labels, and of what, for example, a correlation with another item may imply. Ultimately, the reader interprets my presentation of the results. Fortunately, there are tools available for enhancing the construct validity of inferences of research findings.

One recommended approach (Wilson, 2005) is to ask members of the target group to fill in the questionnaire and gather evidence for construct validity from the data. For example, a qualitative discussion with the participants about the questionnaire items and their interpretation of them would offer insight into how well the intended operationalization of a theoretical concept has worked. The Lily study used this approach by having groups of potential respondents answering the questionnaires followed by a discussion. The discussions led to revisions in the questionnaires and guided the interpretation of the responses to the final questionnaires. One could also gather quantitative evidence for construct validity through factor analyses or correlations (Gable & Wolf, 1993). The Lily study did not conduct a quantitative pilot study that allowed for such tests to be done prior to the main data collection. However, construct measures were created by use of exploratory factor analyses so that evidence – or lack thereof – for construct validity was demonstrated as part of the main analyses: Construct measures were created when there was sufficient covariance between clusters of items, and where there was theoretical support for each specific clustering of items. Following these criteria strengthens construct validity (Gable & Wolf, 1993). I would like to give some examples of how construct measures in the Lily study were founded in theory and science education research literature in a manner that supports construct validity.
In Article II (Bøe, 2012) six construct measures were created that measured the relevant importance of interest-enjoyment value, self-realisation value, fit to personal beliefs value, utility value for university admission, relative cost, and expectation of success for the students’ choice of upper secondary programme area (TABLE 3).

TABLE 3: Construct measures with questionnaire items as given in Article II (Bøe, 2012).

<table>
<thead>
<tr>
<th>Construct measures</th>
<th>Questionnaire Items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interest-enjoyment value</strong></td>
<td>That I would have fun with the subjects</td>
</tr>
<tr>
<td></td>
<td>That I would learn about something I am interested in</td>
</tr>
<tr>
<td><strong>Self-realisation value</strong></td>
<td>That I would be able to develop myself</td>
</tr>
<tr>
<td></td>
<td>That I would be able to use my talents and abilities</td>
</tr>
<tr>
<td></td>
<td>That I would be challenged</td>
</tr>
<tr>
<td></td>
<td>That I would be able to work creatively</td>
</tr>
<tr>
<td><strong>Fit to personal beliefs value</strong></td>
<td>That I would learn about something I find important and meaningful</td>
</tr>
<tr>
<td></td>
<td>That I would learn about something that fits my beliefs and values</td>
</tr>
<tr>
<td></td>
<td>That I would learn about something that is important for society</td>
</tr>
<tr>
<td><strong>Utility value for university admission</strong></td>
<td>To collect as many credits as possible</td>
</tr>
<tr>
<td></td>
<td>Entrance requirements for further studies</td>
</tr>
<tr>
<td></td>
<td>To keep many options for further studies open</td>
</tr>
<tr>
<td><strong>Expectation of success</strong></td>
<td>My previous marks</td>
</tr>
<tr>
<td></td>
<td>My chances to get good marks</td>
</tr>
<tr>
<td><strong>Relative cost</strong></td>
<td>That the programme area would not be too difficult</td>
</tr>
<tr>
<td></td>
<td>That the programme area would not demand too much work</td>
</tr>
<tr>
<td></td>
<td>That I would have time for things beside school work</td>
</tr>
</tbody>
</table>

*Note.* The question was “How important were the following factors for you in your choice of programme area?” on a scale from *Not important* (1) to *Very important* (4).

The construct measures in TABLE 3 measured the importance students put on expectation of success in various subject options and the subjective value they perceived these subject options to have for them. They did not measure the actual interest-enjoyment value of, for example, physics as perceived by students who did or did not choose physics. This distinction is important to keep in mind through the following discussion.
The construct measure *Interest-enjoyment value* measured the importance respondents placed on how interesting and enjoyable they perceived the available subject options would be, when they made their choice. Thus, we can picture respondents who evaluated their own subjective interest-enjoyment value of, for example, physics, mathematics and chemistry, and then placed more or less importance on this value when they decided whether or not to study these subjects. According to the Eccles et al. model, interest-enjoyment value is the “enjoyment the individual gets from performing the activity or the subjective interest the individual has in the subject” (Eccles & Wigfield, 2002, p. 120). The items included in Interest-enjoyment value in article II asked how important it was for the respondents that they would have fun with the subjects, and that they would learn about something they are interested in. The construct measure is, therefore, theoretically well founded in the Eccles et al. model. Interest in science – or lack thereof – has been identified as a predictor of young people’s science-related choices (see Article I).

The construct measure *Self-realisation value* measured the importance respondents placed on how well they believed the subjects would offer opportunities for self-realisation. The term self-realisation is not used in the Eccles et al. model. Nevertheless, I argue that self-realisation value, as operationalized in TABLE 3, measured the importance of parts of attainment value. Attainment value is by Eccles (2009) conceptualised in terms of personal and collective identities. Choosing a subject may be a student’s way of confirming or disconfirming important aspects of their identity, e.g. competence in certain domains, masculinity or femininity (Eccles & Wigfield, 2002). Sociological theories on late modernity describe a culture of self-realisation, where constructing and developing one’s identity is a central task for the individual (Illeris, Katznelson, Simonsen, & Ulriksen, 2002). In their identity development young people wish to use and develop their abilities, to fulfil and realise their potential. The items in the construct measure Self-realisation in article II asked how important it was for the respondents that they got to develop themselves, use their talents and abilities, be challenged, and work creatively. I argue, therefore, that it measures the importance the respondents placed on self-realisation when they made their choice, and that this aspect is part of attainment value.

The construct measure *Fit to personal beliefs value* measured, in my opinion, also part of the importance of attainment value. The items asked how important it was for the respondents that they got to learn about something they found to be important and meaningful, that fit their beliefs and values, and that was important to society. Young
people’s identity, of who they are and want to become, is made up of several components (Eccles, 2009). For example, conceptions of one’s personality, one’s long range goals and plans, and one’s instrumental and terminal values (e.g. responsible, helpful, independent (instrumental), and equality, freedom, a world at peace (terminal) (Rokeach & Ball-Rokeach, 1989)). Thus, the items measure the importance of choosing subjects that students could identify with personally, that is subjects that had attainment value for them. As Fit to personal beliefs value and Self-realisation value is related to the same theoretical construct, it was not surprising that they correlated quite strongly. Moreover, the Eccles et al. model predicts that all parts of subjective value correlate, especially interest-enjoyment value and attainment value. Such a relationship was indeed found in Article II.

The construct measure Utility value for university admission measured the importance respondents placed on how the subjects helped them qualify formally for entrance to higher education studies. According to the Eccles et al. model, utility value “is the value a task has because it fulfils a less personally central goal” (Eccles, 2009, p. 83). The items in the construct measure asked about the importance of collecting credits (that are added to one’s grade point average), satisfying entrance requirements, and keeping many options open for further studies. These are, I argue, values that school subjects may have that are less personally central than, for example, interest-enjoyment value. The measure is, therefore, consistent with parts of the theoretical construct of utility value. It may, of course, be personally central to gain entry to a study programme that has been a lifelong dream. In that case, utility value is likely to be internalised and correlate with attainment value and interest-enjoyment value. For other students, physics and mathematics may be less personally interesting, but the utility value of the subjects may be high because they are required for studies in medicine. Both dimensions are part of utility value as described by Eccles and Wigfield (2002).

The construct measure Expectation of success measured the importance respondents placed on their expectation to succeed with the subjects. The Eccles et al. model defined expectation of success as “individual’s beliefs about how well they will do on upcoming tasks” (Eccles & Wigfield, 2002, p. 119). Theoretically, the model separates this task-specific expectation from the individuals’ beliefs about their own abilities. However, Eccles and colleagues have found that for children and young people, expectation of success and ability beliefs are empirically indistinguishable (Eccles, 2009; Eccles & Wigfield, 2002). The items asked about the importance the respondents placed on their previous marks and
on their chances to get good marks. In interpreting these items to measure the importance of expectation of success lies an assumption that success in a subject means getting a good mark in that subject. What constituted a ‘good’ mark, however, depended on what each respondent perceived to be a good mark for them. The students’ previous marks are likely to largely influence their beliefs about their ability in similar subjects and their expectation for getting good marks in such subjects. In this sense, the items tap into expectation of success and ability beliefs. However, as these aspects have been found to be empirically indistinguishable for young people (Eccles, 2009; Eccles & Wigfield, 2002), this poses less of a threat to construct validity. I believe it is safe to assume that upper secondary students perceive their achieved mark to be a substantial part of what defines whether or not they succeeded in the subject. Nevertheless, there may be more to it as well, that we did not measure. For example, experiences of mastery or ability to explain subject matter to other people. That such aspects were not included in the measure weakens its construct validity. Moreover, the fact that the measure consisted of only two items made it more vulnerable in terms of reliability, as demonstrated by a weak Cronbach’s alpha. Consequently, scores on the expectation of success construct was not emphasised in the results of the Lily study (see Article II).

The construct measure Relative cost measured the importance the respondents placed on avoiding particularly difficult, demanding and time consuming subjects. In the Eccles et al. model relative cost is conceptualised as “negative aspects of engaging in the task, such as performance anxiety and fear of both failure and success, as well as the amount of effort needed to succeed and lost opportunities that result from making one choice rather than another” (Eccles & Wigfield, 2002, p. 120). The items in the measure asked about the importance the respondents placed on the subjects not being too difficult, not demanding too much work, and on that they would have time for things beside school work. These items are all easily identified as descriptive of relative costs.
TABLE 4: Correlations between construct measures

<table>
<thead>
<tr>
<th>Construct measures</th>
<th>IE</th>
<th>SR</th>
<th>FB</th>
<th>ES</th>
<th>UT</th>
<th>RC</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE</td>
<td>1</td>
<td>.56**</td>
<td>.51**</td>
<td>.25**</td>
<td>n.s.</td>
<td>.10**</td>
</tr>
<tr>
<td>SR</td>
<td>1</td>
<td>.53**</td>
<td>.27**</td>
<td>.21**</td>
<td>n.s.</td>
<td></td>
</tr>
<tr>
<td>FB</td>
<td>1</td>
<td></td>
<td>.27**</td>
<td>.14**</td>
<td>n.s.</td>
<td></td>
</tr>
<tr>
<td>ES</td>
<td>1</td>
<td>.38**</td>
<td></td>
<td>.20**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UT</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.12**</td>
</tr>
<tr>
<td>RC</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IE = Interest-enjoyment value
SR = Self-realisation value
FB = Fit to personal beliefs value
ES = Expectation of success
UT = Utility value for university admission
RC = Relative cost
n.s. non-significant
** p<0.01

TABLE 4 shows correlations between the construct measures in the upper secondary population. The Eccles et al. model predicts all the aspects of subjective value to correlate internally, and with expectation of success (Eccles & Wigfield, 2002). As expected, the correlations are strongest between the three intrinsic aspects: interest-enjoyment, self-realisation and fit to personal beliefs. Relative cost correlates to very little extent with the other aspects, which is not surprising considering it concerns negative parts of a subject or a study. The correlations thus support the criterion-related validity of the construct measures.

There is no doubt that there are aspects of the theoretical constructs in the Eccles et al. model that we have not measured the importance of in the work presented here. For some of the measures this was premeditated. Utility value for university admission was designed to measure the importance the respondents placed on choosing subjects that would help them gain entry to many higher education programmes after upper secondary school. The reason for this specific focus was that several studies have found this type of utility value to motivate many students to participate in upper secondary science subjects (see Article I). Similarly, Relative cost aimed specifically at measuring the importance respondents placed on avoiding difficult and time consuming subjects, as science and mathematics subjects are
generally viewed especially difficult and demanding (see Article I). Costs in terms of, for example, lost opportunities were not included.

A few of the construct measures in Articles II and III only include two items. Few items increase the likelihood that the measure lacks parts of the theoretical construct we try to measure. This may limit construct validity as discussed above for Expectation of success. Construct measures with few items also tend to be less reliable measures. I have, nevertheless, made inferences based on scores on measures containing only two items, when I have found the evidence of construct validity and reliability to be satisfactory. This applies to Interest-enjoyment value in Article II, and the importance of Self-realisation and Research in a future job in Article III. Evidence of satisfactory reliability was in those cases demonstrated by Cronbach’s alpha. Arguments for construct validity were found in clear founding in theory and/or additional information about what respondents may mean when they responded to the items, namely focus group interviews and responses to open-ended questions in the questionnaire.

If the constructs presented in Articles II and III are to be used in a new study, it may be fruitful to add a qualitative component, such as in-depth interviews, where possible interpretations of the questions among respondents are explored more thoroughly.

**Generalizability**

For results to be generalizable to a population the sample must be representative for the population, and the probability that the result can be true for the sample but not the population must be established as sufficiently low (by means of confidence intervals).

To ensure representativity, steps may be taken during sampling procedures. Random sampling followed by a high response rate establishes as probable that a sample is representative for the population it was sampled from. Random sampling also reduces bias caused by random errors of measurement. Due to a low response rate of 58%, the random sampling procedure was not enough to ensure representativity of the upper secondary sample. The representativity is, therefore, argued for by comparisons between the sample and the population. The comparison strengthens the generalizability of the inferences made from the results, but it does not provide the same level of support as a 90% response rate. For schools with three or more parallel groups (classes) in the target group, two groups were randomly selected to participate. The number of students participating in each school was therefore limited to approximately sixty. The procedure was employed to avoid
overrepresentation of students in large schools. Nevertheless, it gives students in schools with more than two parallels a lower probability than other students of being sampled, as they had to be sampled twice. 23 of the 42 participating schools fell into this category. Consequently, the procedure may have contributed to underrepresentation of students in large schools, which to some extent would limit the representativity of the sample. However, I decided not to use weighing as a means to counteract any such effect. The Lily study did not measure performance, where between-school variation and dependence on socio-economic background are often discussed. Performance and socio-economic background are likely to influence young people’s educational choices. Although Kjærnsli and Lie (2011) found that actual performance were much less influential on the intended job plans of PISA respondents in Norway than self-concept of ability. Moreover, the Norwegian report from PISA 2009 documents that, compared to most other countries, differences between Norwegian schools are very small in terms of students’ performance in PISA and socio-economic background (Olsen & Turmo, 2010). There are large differences between students, but these are mainly found within schools and classrooms. The situation is not directly comparable to the upper secondary schools in the target population of Lily, as PISA tests 15-year-old students in lower secondary schools, which are part of Norwegian compulsory education. Compared to the PISA schools, therefore, the Lily target schools have a selection of students (roughly 40% of the age cohort in 2008 (NDET, 2009)), which most likely leads to less variation within schools and potentially more variation between schools. The TIMSS Advanced study in Norway found larger variation between schools in students’ upper secondary physics performance than has been found in lower secondary TIMSS and PISA studies in Norway, but this variation was still smaller than in most other countries (Lie, Angell, & Rohatgi, 2010). Another reason why there is larger variance between schools in TIMSS Advanced than in PISA, is that TIMSS Advanced sampled school classes as opposed to PISA which samples schools.

To ensure that specific results can be generalised to a population, significance tests must be done that measure the probability of results occurring in the sample if they are not valid for the population. Such probabilities ($p$-values) are generally considered sufficiently small if they are $<$0.05 or $<$0.01, corresponding to 95% and 99% confidence intervals, respectively. A 99% confidence interval was consistently used to evaluate the statistical significance of results in Articles II and III. This seemingly conservative criterion was
employed because the cluster sampling of schools, as opposed to randomly sampling students, implies that the true standard error is larger than what is observed in the data.

As the entire population of tertiary STEM students (and certain non-STEM students) were included in the Lily study, generalizability to the population is, therefore, not an issue. More on data collection and coding procedures for Lily in higher education is found in Schreiner, Henriksen, Sjaastad, Jensen, and Løken (2010).

For results to be generalizable over time, say to students in Year 12 Specialization in General Studies in years later than 2008 (when the data were collected), one must argue that there are no reasons for these groups to differ in their responses. If significant changes occur, in society, culture or the educational system, one should exercise caution in generalising over time. For example, the data were collected just prior to or at the time in 2008 when the global financial crisis occurred. The 2009 cohort of students in Year 12 Specialization in General Studies, if asked about their priorities in a future job, may have placed more importance on getting a secure job than the respondents did in 2008 due to the comparatively higher uncertainty in the labour market at the time.

The results presented in this thesis concern Norwegian students in upper secondary and tertiary education, and are not directly valid in other countries or educational settings. However, many of the trends in STEM enrolment found in Norway are also seen in many other highly developed countries, and it is likely that some of the results are transferable to countries were the educational system and other relevant background parameters are similar to those of Norway.

Validity issues concerning the Likert scale

There are validity issues that should be mentioned concerning our use of the Likert scale. First, items using Likert response scales produce ordinal and discontinuous data. It is, therefore, not unproblematic to use the data in statistical software algorithms that assumes continuous, and sometimes normally distributed, data. The work presented in this thesis has extensively used mean scores, effect size calculations, independent sample t-tests of statistical significance, correlation analyses, and factor analyses, all of which treat the data as continuous and usually normally distributed. This is, of course, an approximation that requires justification. We have justified it by consistently discarding items where skewness and/or kurtosis indicated non-normality beyond what has been found to be acceptable (Curran, West, & Finch, 1996). Another argument that supports the approximation of the
data as continuous and normally distributed is the large sample sizes in Lily (for example 1,628 upper secondary respondents). Bias in structural equation modelling (e.g. factor analyses) caused by non-normality or categorical nature of the data decreases with sample size (Finney & DiStefano, 2006).

Second, the number of response categories used is important, as too few categories may fail to discriminate between respondents, and too many may cause confusion and frustration (Gable & Wolf, 1993). Five category scales have been found to be a good compromise and are commonly used. The four-point scale used in the Lily study may, therefore, not have discriminated perfectly between respondents. A few items with large floor- or ceiling effects indicated such problems. These items were discarded prior to factor analyses, and otherwise not reported on. Nevertheless, the four point scale was chosen. We wanted an even number scale to avoid a neutral mid-point category. We chose four instead of six categories to limit the risk of confusing and frustrating respondents, which would threaten the validity of the data. The inclusion or not of a neutral mid-point category has long been debated, and no clear recommendation can be found. On the one hand, argued Gable and Wolf (1993), including a mid-point category allows the respondent to express an opinion that is neutral, whereas an even number scale deprives the respondent of this option. In this sense, the odd number scale may be more reliable. On the other hand, the even number scale forces the respondent to think more carefully about their answers, leading to more precise discriminations. Gable and Wolf continued to argue that respondents may use a mid-point category to express quite different opinions: neutrality or indecision about the statement, indifference to the statement, lack of understanding of it, and refusal to answer. Such ambiguity poses a threat to validity. Given as the target group in Lily comprised teenagers, it was a priority to force respondents not to be indifferent, and to avoid confusing or frustrating them.

It should be mentioned that there are alternatives to the Likert scale. One example is Guttman scales (Robson, 2002) which commonly consist of statements which respondents accept or decline. These statements are designed in a cumulative fashion, where accepting one statement implies that you also accept all previous statements. Guttman scales are constructed to be unidimensional as opposed to Likert scales where several dimensions may influence responses to an item. Guttman scales are, therefore, said to be easier to respond to and to interpret results from (Wilson, 2005). One downside to using Guttman scales are that it requires many items, which limits the constructs one can measure within a questionnaire.
Another downside is that it is best suited to measure a well-defined dimension (Robson, 2002). Not all research questions concern such clear-cut dimensions. Many of the constructs we attempted to measure in Lily are by definition complex and multifaceted, and correlated to each other. In total, we found the Likert scale to be the best choice for our purposes. Several other large scale studies also employ Likert scale formats, such as PISA and Eurobarometer (European Commission, 2011).

2.6 Limitations

The discussion above has demonstrated a few limitations to the work presented in this thesis. I refer mainly to the 58% response rate among upper secondary schools, to the lack of a quantitative pilot study, to the construct measures that have only two items, and to the approximation of the four-point Likert scale as continuous. There are also a few other limitations that should be mentioned. First, the literature review presented in Article I was not a systematic review generated by a library database search and a predefined protocol for how the literature should be evaluated and analysed. The literature was found by the authors’ own searches in databases for scholarly articles as well among books and articles the authors already knew about from their work. Therefore, the review may lack references to work that should have been included. However, the science education research field is small compared to, for example, the natural sciences or medicine where systematic reviews are common. Consequently, the field is rather manageable. Another aspect of a systematic review that our review lacks is a thorough scrutiny of the validity of each study reported in the review, beyond what is found in the articles. When reviewing literature for Article I we based our assessment of the quality of the research on what was reported in the articles. Beyond this, we were forced to rely on the peer review and editorial control processes to ensure the validity of the reported results.

Another possible limitation to this work is that the Eccles et al. model is developed based on empirical results from the US. There may be differences between the Norwegian and US contexts that limit the model’s suitability as a theoretical framework for a Norwegian study. However, article I argues well for the use of the Eccles et al. model also outside the US as long as certain conditions are present, such as only small differences in social development levels (see Article I).

The final point I would like to make is not necessarily a limitation, but an acknowledgement of a possible different approach. The methods of analyses used in this
work belong to classical test theory. Alternatively, modern test theory approaches may have been employed, for example, the Rasch item response theory model (see e.g. Wilson, 2005). I believe I have demonstrated that the classical methods used have been done sufficiently thoroughly to produce valid results. Nevertheless, there is obvious potential in applying modern test theory to studying young people’s educational choices, and I plan to pursue this in the future.
3 Summary of main findings

The three articles present the results of this work, which will not be thoroughly repeated here. To prepare readers for the discussion chapter, however, the main findings are described very briefly in the following section.

Article I reviews international research about young people’s relationships to and participation in STEM subjects and careers, through the lens of an expectancy-value model of achievement-related choices (Eccles et al., 1983). The literature review establishes that young people’s interest in school science and mathematics is relatively low, and tends to decline as they progress through school. The subjects are often characterised as having transmissive pedagogy, and unengaging, de-contextualised content. However, students often show more interest in science topics, and regard science and mathematics as important in general but less so for them personally. They struggle to identify with STEM culture and with STEM professionals, and often find them ill-suited to their identity. Some students tend to choose post-compulsory science subjects for instrumental reasons: for example, to gain admission to a preferred university or to keep many options open. Science subjects are often perceived as particularly difficult, and this affects students’ expectation of success in these subjects, which tends to be lower than their expectation of success in other school subjects. The literature reveals gender differences in several aspects of young people’s relationship to science, aspects that are predicted by the Eccles et al. model to affect educational choices: Females are more likely than males to have low expectation of success and associate considerable costs with studying science and mathematics. Females are less likely than males to identify closely with science disciplines and professionals, and there are clear average differences in which science topics males and females are interested in.

Article II investigates the importance of various issues in 1,628 Norwegian upper secondary students’ choices of post-compulsory subject combinations: Natural science and mathematics (henceforth Science) or Languages, social science and economics (henceforth HumSoc). Interest-enjoyment and fit to personal beliefs were somewhat less important to Science students than to HumSoc students, especially to girls taking Science. Utility value for university admission was much more important to Science than to HumSoc students, and more important to Science girls than to Science boys. Keeping the costs low in terms of time and effort were much more important to HumSoc than to Science students. The findings indicate that the students chose Science both for identity reasons – such as interests, self-
realisation and fit to personal beliefs – and for strategic utility reasons. Some of the students, especially girls, appear to have placed more weight on utility than on their interests.

Article III uses questionnaire data from Norwegian physics students in upper secondary (N=585) and first-year tertiary (N=278) education to characterize the “physics choosers”. Secondary students were largely motivated by interests, self-realisation and/or the utility value of physics for university admission, and many of them planned to go into medicine (females in particular) or engineering (males in particular). Tertiary physics students appeared to be motivated by a passion for the subject, high interest and expectation of enjoyment, and many of them planned to go into research. Females expressed lower self-concepts of ability than males, and were more idealistically oriented concerning future job. However, gender differences were less prominent among tertiary than secondary students. The results indicate that tertiary physics students were well adapted to a physics discipline culture, where the subject in itself is emphasised. Moreover, the results suggest that upper secondary physics has a window of opportunity to introduce students to a wide range of career options in physics.
4 Discussion

Each of the three articles included in this thesis discussed implications for post-compulsory participation in STEM (in the case of Article III: physics) and recommended measures that may be taken if the goal is to improve participation. Several of the suggested measures were aimed at school science. Consequently, questions are triggered about what school science should be like. What are its purposes? Who is school science for? What should be taught, and how? The research I have done does not equip me to fully answer these questions. Moreover, I am not in a position to normatively conclude that our recommendations should be put into action. If, where, when, and to what extent measures should be taken to improve participation in STEM, depends on a range of factors that often rely on local conditions and contexts. Article I described the nature and scope of STEM participation problems, and argued that there are reasons for concern. Nevertheless, I recognise the moral questions related to systematically encouraging young people to pursue STEM careers in complex and unpredictable job markets, as argued by Osborne and Dillon (2008) and Quinn and Lyons (2011).

4.1 Promoting STEM participation in the school sciences

The primary aims of compulsory school science and how these best are achieved have been subject for debate among science educators for decades. One dimension in this debate has concerned the tension between a ‘science for all’ aiming to educate the general public in and about science, and a ‘science for future scientists’ focused on preparing students for specialising in science (see e.g. Donnelly, 2005; Fensham, 2002; Layton, 1973; Osborne & Dillon, 2008). According to Turner (2008), the 1980s saw widespread curricular reforms towards a ‘science for all’: less emphasis on content, university preparation, and excellence, and more on minimum standards for all students, on science and technology, and responsible citizenship. The latter is often referred to as the “scientific literacy” movement, though there is ambiguity as to what the term “scientific literacy” entails (Donnelly, 2005; Roberts, 2007; Turner, 2008). In the following sections I will demonstrate that several of the proposed recommended measures that may be taken to improve participation in STEM are compatible with recommendations for a general science education as argued for by science educators. I will also point to some challenges and dilemmas that may arise, and identify issues that should be investigated in further research.

8 In ‘school science’ here I include integrated compulsory science courses as well as other discipline-specific post-compulsory courses, for example, physics.
How these recommendations may contribute to improved gender balance in STEM is discussed in the last section of this chapter.

**Increased emphasis on context and science, technology and society (STS) issues**

The suggestions we have made as to how young people’s participation in STEM may be improved include increased emphasis on science in context and on STS issues, for example, on the role of science in work with global challenges such as climate change, renewable energy, and health care. Moreover, we have proposed that young people’s educational choices should be seen as identity choices, and suggested that students should be introduced to a variety of STEM career options, where a wide range of priorities, interests, and self-realisation projects can be met. A school science that meets these recommendations has several properties in common with ‘science for all’ approaches. Work done by a large group of European science educators resulted in the report *Science Education in Europe: Critical Reflections* (Osborne & Dillon, 2008). The report stated that the primary goal of compulsory school science in the EU should be “to educate students both about the major explanations of the material world that science offers and about the way science works”. Further, the authors called for innovative curricula and ways of teaching that address low student motivation, for considerations of the compatibility of school science to young people’s identities, and for a focus on career opportunities in science and how these are “valuable, worthwhile and rewarding”. The results presented in this thesis imply that a majority of young people wants to learn about and eventually work with matters they perceive to be important – to themselves and to society. However, I would argue that the use of socio-scientific issues is beneficial beyond engaging students in school science or attracting them to take post-compulsory science. I believe it is of great importance to educate future scientists who really care about such issues, to provide the devotion and dedication required to find innovative solutions to important challenges in society.

**Supporting interest and enjoyment**

In the work presented in this thesis, interest and enjoyment have emerged as key motivational factors for young people’s choices to study – or not study – science. Based on these findings, we have suggested that supporting students’ interests is central if participation is to be improved, for example, by taking advantage of the fact that interest in science topics ‘per se’ tends to be higher than interest in traditional school science. Osborne and Dillon (2008) advocated that engaging students with science and scientific phenomena
should be the emphasis of the curriculum before the age of 14. I believe that students’ desire to be interested and engaged in their subjects should not be under-estimated even at later ages. A large proportion of the students in the Lily study appeared to be constantly negotiating their choices, and focused on keeping their options open. Their delayed decision-making suggests that even at the post-compulsory level, the school sciences must continue to intrigue students. In this sense, the traditional way of teaching science brick by brick, concept by concept, law by law – before being able to admire the fascinating edifice, is ill-suited to engage not only the majority of students who will not become scientists as argued by Osborne (2007), but also many potential future scientists. Fensham (2002) claimed that students must have the opportunity to encounter the excitement and wonder of science if enough of them are to be attracted to pursue scientific careers, for what he refers to as “good intrinsic reasons”. We would like to know more about how innovative approaches to science curriculum and instruction may affect students’ interests and their willingness to choose post-compulsory science.

Moving towards more inclusive discipline culture in physics

According to the results in Article III, Norwegian students who had chosen to study tertiary physics were largely inspired by popular science and its excitement and wonders. The passion for the subject that is evident among most of these students should be maintained. Nevertheless, we have proposed that the physics discipline culture – as enacted in upper secondary physics in particular – may have to adapt to become more inclusive of students with broader motivations than passion for the subject alone. This proposition requires a clarification about what we mean by the physics discipline culture, of who its practitioners are, and who secondary and tertiary physics studies are for.

For the purpose of our discussion, the term physics discipline culture refers to the practices and values that dominate and are endorsed in secondary physics classrooms and university physics studies. Examples of such values are described in Article III, and include an orientation towards physics content and basic laws rather than on physics history, contexts and processes, and the notion that passion for the subject itself is the only valid motivation for studying physics. Physics culture practitioners in this sense include university physics professionals, secondary physics teachers, and to some extent also secondary and tertiary physics students. One may also argue that many professionals using their university physics degree in applied physics-related occupations are physics culture practitioners, but these have less direct influence on students.
What secondary and tertiary physics students require is clearly not the same. Upper secondary physics students will end up in a wide range of university studies and later occupations, and the physics they encounter in upper secondary school should meet very diverse needs and motivations. Specifically it has to encourage students to learn about a range of applications of physics, as well as basic content knowledge. According to Einevoll (2007, p. 13), “physics is investigations of nature aimed at developing mathematical models” (my translation). A university study in physics as a discipline, therefore, will by necessity be dominated by basic content-knowledge, rational discourse and substantial mathematical rigor. However, the research literature suggests that upper secondary physics practices, too, emphasise these aspects at the expense of physics in historical and social contexts (Carlone, 2004; Duit, Niedderer, & Schecker, 2007; Häussler & Hoffmann, 2000; Krogh & Thomsen, 2005; Lie et al., 2010; Osborne & Collins, 2001). Moreover, I’d argue that also in the university, in particular at low undergraduate levels, students should be able to recognise the many different ways in which master-degree level physics knowledge may be applied. One reason for this argument is that many of those who graduate from physics studies end up working as applied physicists. Another reason is that important challenges in society require solutions by university-trained physicists. I am not proposing that students who have no interest in physics should study it. On the contrary, I believe that interest is a requirement for successfully completing a university study in physics. However, students who are motivated also by the applications of physics or by its importance for socio-scientific issues should be able to identify with the values of the culture – in tertiary as well as secondary education.

The notion of science as fixed knowledge handed down from teacher to student, presented as packages of decontextualized basic concepts, appears in the literature as particularly alienating. In addition to a desire to learn about something they saw as meaningful, many students in the Lily material valued working creatively in their subjects and in a future job. I will not go into definitions or distinctions between inquiry-based science education, nature-of-science approaches, and argumentation approaches. I will, nonetheless, like to mention that such classroom practices may also contribute to make the subjects more inclusive by emphasising other work forms than the transmission of fixed knowledge from teacher to student. What these practices should entail more specifically is a field of research in itself. How they may affect enrolment and persistence in post-compulsory science requires further research.
Proposing changes to the discipline culture of, for example, physics points to some challenges. First, traditional physics culture is endorsed by both teachers and students (Angell et al., 2004), and suggestions of change are likely to be opposed by many of its practitioners. Fensham (1997) claimed that leading scientists often opposed changes to science in the final years of schooling, out of a fear of losing “the narrow, but concentrated, preparedness of their first-year students in the physical sciences”. How changes should be implemented, where they should be implemented – in secondary and/or tertiary physics – and what kind of changes may be appropriate at the different levels requires thorough investigation. Moreover, we must expect any adaptation to take time. The other challenge involves keeping those students who like and identify with traditional physics culture. Can we find a way to make physics culture more inclusive without losing those who already love it? Physics needs more and different people to develop in new, constructive ways (Schiebinger, 2008), but the field also needs the participants that are driven by their passion for the subject. There is a need for more research on how physics culture may change to become more inclusive, on how efforts to do so have worked, including how teachers and other practitioners welcome and/or resist such change.

We would also like to know more about how innovative approaches to science curriculum and instruction affect students’ learning and performance. Turner (2008) observed that there had been a retreat from curricular reforms focused on ‘science for all’ back to more content-based, traditional approaches in the US, and that this retreat appeared to be motivated by increased focus on economic competitiveness and the results on standardised tests such as TIMSS and PISA. In Norway there is also concern about decreasing performances in mathematics, science and physics as measured by standardized tests (Kjernsli & Roe, 2010; Lie et al., 2010). One can identify a shift in the latest Norwegian curricular reform ‘Knowledge Promotion’ towards an orientation on competence and skills (Dale & Øzerk, 2009). Angell, Lie, and Rohatgi (2011) linked the decline in physics competence of Norwegian students, seen in results of TIMSS Advanced 2008, to unsatisfactory learning of algebra from previous school years. It is important that measures taken to improve students’ willingness to study science also support their learning, to ensure that future students can cope with tertiary science studies. Future scientists need more of the basic science knowledge and skills than the majority of learners who will not pursue a STEM education. At what point, however, the needs of these two groups of learners become impossible to meet in one common science curriculum is not clear. More work is needed in
this respect related to the Norwegian context, in particular, research on how the recent curricular reform influences students’ engagement and learning in science, and their willingness to pursue post-compulsory science.

**Reducing the perceived costs of science relative to what it offers**

We have suggested that post-compulsory participation in STEM may be improved by reducing the perceived cost of STEM subjects relative to the benefits they offer. A specific recommendation was to promote support in study groups or mentor programs. One could also argue that more focus on overall pictures and less on decontextualized blocks of content knowledge may reduce the difficulty. A less common suggestion, perhaps, was to advocate the sciences as subjects that offer challenges and self-development because of their costs. For example, educators have argued that physics may be inherently difficult, due to its many forms of representation (Dolin, 2002), high level of abstraction (Duit, 2007), and a way of thinking in the physics classroom that requires a border crossing from the students’ everyday world (Krogh & Thomsen, 2005). Results from the Lily study reported in Articles II and III revealed that the students valued the opportunity to use their talents and abilities, be challenged and develop themselves in the sciences. As it is the students’ perception of the costs that affects their willingness to pursue the subjects, it may be beneficial to emphasise how the same properties of the subjects also offer some positive aspects.

**Supporting the influential teachers**

The majority of our recommendations for how post-compulsory participation in science can be improved involve teachers directly or indirectly. The importance of good and well-qualified teachers for students’ engagement and participation in school science cannot be overrated. They have the ability to foster interest and enthusiasm, employ a variety of teaching approaches, introduce a range of applications and socio-scientific issues, support students’ expectation of success and call attention to the positive aspects of being challenged, and they can be examples of science identities. There is a great need in many countries for more skilled science teachers (ICSU, 2011). Moreover, science teachers must be supported in attempts to adopt innovative curricular approaches. As argued by Osborne (2007, p. 181), “changing the curriculum is one thing. Asking teachers to change their pedagogy to meet the demands of such a curriculum is another.”
4.2 Improving female participation in STEM

Article I laid down three premises for my focus on gender in this thesis. First, it documented that women are under-represented in most STEM subjects. Second, it reviewed research literature that revealed specific gender differences related to all the major five aspects in the Eccles et al. model: expectation of success, interest-enjoyment, attainment, utility, and relative cost. Third, it gave specific reasons for why we believe that more females in particular should participate in STEM. With these premises laid, Articles I, II and III all point to measures that may be taken to increase the participation of females in STEM education and occupations. For example, they propose that teaching science in society contexts, presenting STEM careers that involve helping other people, focusing specifically on increasing expectation of success, and promoting a physics culture that support a broader set of motivations and practices, may be helpful in increasing the participation of females in STEM. Among the reasons given in Article I for improving the gender balance in STEM, were that such an increase may bring different experiences, perspectives, and practices to the table, and that the participation of more women will strengthen women’s empowerment and help reduce the stereotypes and expectations that limit women’s freedom in choice of education. In addition, there is an untapped pool of resources among women in terms of increasing the number of STEM professionals in general.

Gender has been used throughout this work as a category to define groups, and parts of the data analyses have been aimed at investigating differences – or lack thereof – between females and males. The rationale behind this choice is described above: the observed under-representation of women in physical sciences, technology and engineering, and the reasons for why this under-representation is a problem. As demonstrated in Article I, the science education research literature documents average gender differences in young people’s relationship to STEM on the expectancy-value constructs interest-enjoyment value, attainment value, utility value, relative cost, and expectation of success of the Eccles et al. model. With the exception of utility value for further education, all the reported differences imply, according to the Eccles et al. model, that females are less likely to choose to participate in STEM. These average differences may not be large compared to the within group variation, which I have chosen to not study here. However, as the differences point in the same direction, against female participation in STEM, their total contribution to the observed differences in course enrolments and occupational choices is likely to be
substantial. Understanding more about this contribution may offer insights into what can be done to improve female participation.

**Recommendations for improved gender balance in STEM**

All the three articles discussed implications for improved participation in post-compulsory science based on the presented results. The results suggest that most of the recommendations aimed at students in general may improve the gender balance in the physical sciences and technology in particular. Among the recommendations were increased emphasis on context and socio-scientific issues in school science, and introducing students to a variety of STEM career options that may be compatible with different identities. We recommended that students’ interest and enjoyment in science are supported, and that diverse interests beyond the subject itself must be met. The costs of science – in terms of difficulty and work load – may be perceived as less discouraging if more emphasis was placed on what science has to offer to the students. We argued for promoting a (school) physics culture that is more inclusive to different motivations, such as applications of physics in work related to global challenges and medicine. These recommendations may lead to increased participation in post-compulsory science, and to more variation in the interests, priorities and practices of the science student pool. In addition, special attention should be given to supporting females’ expectation of success in science and mathematics, and their identity formation in discipline cultures dominated by males and sometimes masculine practices.

**More than more of the same**

As stated above, improved participation in STEM entails more than an increase in numbers of participants. It entails a greater variety of priorities, experiences and practices among the participants. Many of the recommendations made in Articles I, II, and III were, therefore, aimed at inviting a broader range of students into STEM, especially those who feel that their interests, values or priorities cannot be met in STEM. As argued in Article III, physics is one of the disciplines where greater variety is needed, alongside a better gender balance. However, there is no guarantee that more women in physics would constitute something beyond ‘more of the same’. In principle, more men may be equally valuable as more women in terms of bringing something new to the discipline. The point, in my view, is to invite students – men and women – who do not feel at home in a traditional physics culture, because they are particularly likely to add something new. What we must conclude, however, from the current under-representation of women and the reports from the research
literature, is that there are more women than men among those students. Thus, a physics culture with a broader appeal is likely to be a more gender-balanced physics as well.

This leads us to a central point: Cultures related to STEM disciplines may have to adapt to invite a larger variety of individuals into the fields. The way in which young people relate to physics or other STEM subjects depends, among other factors, on how they experience and expect to experience the subjects (Eccles, 2009). Physics has been characterised by practices often identified as masculine (Murphy & Whitelegg, 2006), and sometimes as discriminatory towards females (Urry, 2008). There are undoubtedly many females who embrace these practices and by no means feel discriminated against by them, females who feel at home in a traditional physics culture. I would say I am one of them myself! However, it should be possible to identify with physics also for females who do feel alienated by such practices, and to allow for that to happen, current practitioners may need to engage actively in promoting change.

By communicating gender differences, we run the risk of strengthening stereotypical notions of females in science, as proposed by Sinnes and Løken (2011). Consequently, it becomes important to distinguish between the individual and the group levels. To gain generalizable information about the STEM-related choices of young people in Norway, a quantitative approach was required. The results gained from this study apply to students on a large, group level. For example, even though females on average scored higher than males on the importance of helping other people in a future job, we can obviously not assume that every female thinks it is important to help others in her future job. Consequently, we would not argue that every female would be more inclined towards a STEM career if it involved helping other people. What we do conclude, and what is suggested by the research literature, is that if a large group of students were introduced to more idealistic career opportunities in STEM (e.g. engineers without borders), more females than males would find them appealing. Such conclusions are, in my opinion, valuable contributions to our understanding of the under-representation of women in STEM.

Additional information on the within gender variation in young people’s relationships to STEM is of great value for the total picture. Quantitative approaches to the study of such variations are valuable, and qualitative studies designed to capture nuances and variety, contribute by broadening the picture drawn from majorities and averages. For example, Brickhouse, Lowery, and Schultz (2000) described how four middle-school girls
in the US related to science in different ways depending on their views on what kind of a
girl they were. Danielsson (2009) studied how women constituted their identity as physics
students in the laboratory setting. Løken (2011) analysed stories from women who had
chosen physical sciences, technology, or engineering, and found that some women felt very
different from the stereotypical notions of women and science. Carlone (2004) reported how
some girls resisted a physics curriculum centred around real-world themes, because they
meant it threatened their good student identities. These studies all contribute to our
understanding of how females may relate to science in very different ways. Some in ways
that make them feel at home in current science culture, others in ways that make them resist
the same culture. The latter, in particular, adds to our understanding of how female
participation in STEM may be improved.

As an added thought, there are striking similarities between many of the perspectives
described in this chapter and two Norwegian reports from twenty-one and almost thirty
years ago: “Upper secondary physics: Who chooses the subject, and why?” by Lie and
Angell (1990) and “‘Soft’ girls in ‘hard’ subjects? About science and equity” (my
translations) by Lie and Sjøberg (1984). The gender imbalance in, for example, upper
secondary physics remains discouragingly unchanged; the differences in interests are largely
the same; and the arguments and suggestions as to how the situation may be improved go
along the same lines. That is not to say that efforts to remove barriers for female
participation in science have been worthless, but rather that the work must continue, also
beyond the science classrooms, as argued by Quinn and Lyons (2011).
5 Concluding remarks

The core of this thesis consists of the three articles that follow. Through addressing different research questions, they contribute to the understanding of Norwegian students’ choices of post-compulsory science. I have adopted an expectancy-value perspective in his work. In short, this means that I have focused on two main questions that young people might ask themselves before deciding whether they should study science or not: “Can I do this?” and “What’s in it for me?”. The articles inform us on how young Norwegians in particular relate to these questions, and they draw on an extensive body of research literature to place the results in an international context. In the rest of the thesis, I have reflected upon the theoretical and methodological choices I have made and upon the implications of the results for the school sciences. I hope the thesis will be a valuable contribution to science education.
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higher education in Norway] KIMEN. Oslo: Norwegian Centre for Science Education.


ARTICLE I

Participation in science and technology: young people’s achievement-related choices in late-modern societies

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Young people’s participation in science, technology, engineering and mathematics (STEM) is a matter of international concern. Studies and careers that require physical sciences and advanced mathematics are most affected by the problem and women in particular are under-represented in many STEM fields. This article views international research about young people’s relationships to, and participation in, STEM subjects and careers through the lens of an expectancy-value model of achievement-related choices. In addition it draws on sociological theories of late-modernity and identity, which situate decision-making in a cultural context. The article examines how these frameworks are useful in explaining the decisions of young people – and young women in particular – about participating in STEM and proposes possible strategies for removing barriers to participation.

Keywords: participation; STEM; educational choice; gender; expectancy-value model; modernity

1. Introduction

A key theme running through much of the recent science education literature has been the increasing reluctance of young people in many parts of the world to participate in science, technology, engineering and mathematics (STEM). Awareness of this disinclination emerged in the early-1990s, with several national reports identifying shortages of science graduates and declines in student interest in school science. As the number of such reports grew, international comparative studies were undertaken to investigate the extent of these trends. The commonalities revealed by these studies across a number of countries has led research in this field to the point where broader explanatory models are now needed to account for the fact that the trend appears to be more closely associated with socio-cultural characteristics of a generation than with national economies or education systems.

This article examines international research about young people’s relationships to, and participation in, STEM subjects through the lens of a contemporary model of achievement-related choices (Eccles et al., 1983; Eccles & Wigfield, 2002). While the article is structured primarily around features of the Eccles et al. model, it also draws
on sociological theories of late-modernity and identity that situate decision-making in a cultural context. The article examines how these frameworks are useful in explaining the decisions of young people – and young women in particular – about participating in STEM and proposes possible strategies for removing barriers to participation.

1.1 The nature and scope of STEM participation problems

One challenge in examining such a multidimensional issue is the difficulty of establishing parameters and internationally comparable terms of reference. In framing the problem at least four interrelated dimensions need to be considered: the range of STEM subjects; the different national contexts; the different critical decisions points; and the patterns of participation among young men and women.

In terms of the first of these, it is recognised that the so-called ‘STEM problem’ does not apply equally to all STEM fields or their component disciplines. For instance, university enrolments in life/heath sciences such as medicine, biology and biochemistry are considered sufficient to meet projected demand in most developed countries (Organisation for Economic Co-operation and Development [OECD], 2008), while supply and demand of ICT graduates have fluctuated wildly over the last decade or so (OECD, 2010b). On the other hand, there are predictions of widespread shortages in most engineering disciplines (United Nations Educational, Scientific, and Cultural Organization, 2010) and many OECD countries report serious under-enrolments in university physics, mathematics and, to a lesser extent, chemistry courses.

It should be noted that such projections of supply and demand are complicated by the economic impact of the global financial crisis (GFC), which not only dampened demand for a wide range of STEM graduates but affected university enrolment patterns in complex and unpredictable ways (see, for example, Institute for International Education, 2010; Paton, 2010; Sursock & Smidt, 2010). Nevertheless, key economic organisations predict a gradual global recovery over the next year or so (International Monetary Fund, 2010; OECD, 2010a) and in view of the long-term trends prior to the GFC documenting an undersupply of STEM graduates in many countries it is entirely possible that following this recovery the general trends of STEM participation over the last two decades will continue where they left off. Certainly there is no indication that the gender disparities in some STEM fields discussed below will be reduced in the wake of the GFC.

It is apparent from the discussion above that in the context of supply and demand trends, STEM is a somewhat generic and ill-fitting term. Nevertheless, given its broad acceptance in the literature it is the most convenient – or perhaps the least inconvenient – shorthand term available for discussing the complex cross-discipline issues addressed in this article.

Consideration of the second dimension – different national contexts – reveals variations within the trends outlined above. First and foremost, young people’s increasing reluctance to participate in physical science and mathematics subjects has been most evident in highly developed and modernised parts of the world such as Europe (European Round Table of Industrialists, 2009; OECD, 2008), the US (Stine & Matthews, 2009), Australia (Lyons & Quinn, 2010), New Zealand (Hipkins & Bolstad, 2005a), Canada (Government of Canada, 2007), Japan (OECD, 2007b; Ogura, 2005) and Korea (Anderson, Chiu, & Yore, 2010). By contrast, research indicates that there is a greater enthusiasm for science and technology careers among young people in less
developed countries (Sjøberg & Schreiner, 2010). It is also likely that many less developed nations will continue to experience lower unmet demand for scientists and technicians than developed or emerging countries (Qurashi, Kazi, & Hussain, 2010). Hence, this article is limited to discussion about STEM supply and demand in highly developed countries.

Even within this group, the nature and extent of the problems vary with national demographics, labour markets and education systems. For instance, engineering graduates are in greatest demand in Australia, Germany, the US, Canada, Norway, the UK and New Zealand (Kaspura, 2010; Manpower, 2009), while serious shortages of physics and chemistry teachers have been reported in the UK, Norway, Denmark, the Netherlands (Osborne & Dillon, 2008), the US (Hodapp, Hehn, & Hei, 2009) and Australia (Department of Education, Science and Training, 2006). There is also contention about the scale and nature of reported shortages, particularly in the US where some researchers have questioned whether calls for increased supply of STEM graduates such as *Rising above the gathering storm* (US National Academies, 2007) are misplaced (Lowell, Salzman, Bernstein, & Henderson, 2009).

A third dimension differentiates the critical points in students’ lives when decisions are made about participating in STEM subjects or careers. Notwithstanding the evidence that students’ conceptions and attitudes evolve gradually and from an early age (Osborne, Simon, & Tytler, 2009), this dimension is also punctuated with formal opportunities – transition points – in secondary and tertiary education. Again, these points vary with the type of education system. In many countries students make their first decision about taking non-compulsory subjects around the age of 15–16 years. Experiences of junior high school science can therefore have a significant influence, since decisions to forgo science subjects generally put an end to any formal science education.

There is substantial evidence that young people have been disengaging from science at this first decision point. In the UK, for instance, the proportion of students taking A-level physics fell from 6.6 to 3.4% between 1990 and 2008, a decline of 49%. The proportion taking chemistry fell from 6.8 to 5%, a decline of 26% (Joint Council for Qualifications [JCQ], 2009). Over the last two years both subjects have registered increases, with 3.8 and 5.2% of A-Level entrants in 2010 taking physics and chemistry, respectively (JCQ, 2010). While an encouraging sign, it remains to be seen whether this upward trend will be sustained.

In Australia, proportionally fewer students have been choosing science at the first decision point. According to Ainley, Kos, and Nicholas (2008), between 1992 and 2007 the proportions of senior high school students taking physics, chemistry and biology courses declined by 26, 22 and 29%, respectively. More recent figures suggest a stabilisation, rather than an upturn as in the UK (Lyons & Quinn, 2010). Researchers in New Zealand have also reported early student disengagement from science and mathematics (Hipkins & Bolstad, 2005b). In many countries, increased student disengagement from STEM has been most apparent in the secondary–tertiary transition. In France, for example, the percentage of high school graduates enrolling in first year university science courses (excluding health and medicine) almost halved from 8.4% in 1995 to 4.3% in 2007 (Arnoux, Duverney, & Holton, 2009). Over the last decade universities in Japan have been increasingly concerned about *rikei banare* or the ‘flight from science’. The number of students studying science and engineering at university decreased by 10% between 1999 and 2007 (Fackler, 2008).
A fourth categorical dimension is gender. There is clear evidence that young men and women in different countries tend to make different choices about STEM participation. For example, the 2006 PISA study reported that in Japan, Korea, the Netherlands, Germany, Iceland and Taiwan 15-year-old boys were significantly more inclined towards future science-related study and careers than were girls. In contrast, results from Sweden, Denmark, Australia, New Zealand and Canada showed little difference in the intentions of boys and girls (OECD, 2007b). In terms of specific STEM subjects, however, young women at school and university tend to be underrepresented in physics, engineering, mathematics and technology subjects and overrepresented in the life and health sciences (Dobson, 2007; European Union [EU], 2006, 2009; NSB, 2010; National Science Foundation, 2006). This gender disparity is reflected in career profiles in these fields.

This situation motivates the specific focus we have on gender in this article and underscores the particular challenge in recruiting more young women to STEM. Exploring the different influences on young men and women is a classic element of studies in science and mathematics education (see, e.g., Eccles, 2007; Jenkins, 2006; Kjærnsli, Lie, Olsen, & Roe, 2007; OECD, 2007a; Osborne et al., 2009; Scantlebury & Baker, 2007; Schreiner, 2006; Sørensen, 2007), with much research addressing gender issues and approaches to gender equity in science and mathematics education (for reviews see Hutchinson, Stagg, & Bentley, 2009; Kenway & Gough, 1998; Spelke, 2005). The observed gender differences in STEM participation are by no means new and have generated debate for several decades. One central issue in such debates is whether or not these differences, so persistent over time, spring from genetic differences, for instance in mathematical aptitude, between young men and women. However, evidence indicates that socio-cultural factors and constraints constitute the most powerful explanatory factor behind women’s under-representation (Ceci, Williams, & Barnett, 2009) and that to the extent that gender differences in mathematics and science achievement are observed, they are small in effect size and often represent an overlap of around 90% in the score distributions of young women and men (Hyde & Linn, 2006).

While acknowledging the interrelationships between and differences within the four dimensions above, this article addresses at its core young people aged 15–20 years from highly developed countries and their relationship with, and aspirations towards, subjects and careers requiring physical science and advanced mathematics. Within this scope the article has a particular focus on the deliberations of young women.

1.2 Five reasons for why participation in STEM is important

The previous section documented how the STEM participation situation is cause for concern. However, we believe that there is more to this issue than simple ‘supply and demand’ considerations. We will present five reasons why more people in general, and more women in particular, should participate in STEM education and careers:

(1) Society needs more people in STEM professions in order to fill current and future demands, for instance, to secure a sufficient and sustainable energy supply, responsible resource use, efficient healthcare in all parts of the world, clever technology development and a sound economy.

(2) STEM needs a greater diversity of professionals (more women in particular) in order to develop in new ways (Schiebinger, 2008). A greater diversity of
experience, perspectives and work forms among professionals may increase the innovative potential and propel STEM forward, helping it adapt to rapidly changing societies and to the diverse purposes and applications of STEM around the world.

(3) Women and other under-represented groups need STEM to be empowered to influence their own lives and the development of the world. These groups should be encouraged to participate with their priorities on the arenas where decisions are made concerning research and technology development. A classical example concerns women’s health, which has received increasing focus in medical research as a result of women’s engagement (National Institutes of Health, 1999). Another aspect of this argument is that the failure of women to pursue STEM careers limits their career opportunities and earning potential. To sum up: involvement in STEM gives people literacy, empowerment and economic freedom to shape their world and everyday life.

(4) Everyone should be given the chance to engage in the wonders of the scientific and technological world, which may enrich their lives and contribute to their individual development. This is in line with the ideals for a liberal education as described for instance by Carson (2002).

(5) Everyone should have a real, not only a formal, free choice of education. The norms, stereotypes and expectations young people meet should allow for a role for women and other under-represented groups in STEM. Stereotypical views of scientists are still prevalent and fit poorly with the ideals that are held up, particularly for young women, by contemporary culture. Young people will not have a real free choice of education before these mental and cultural barriers are reduced.

1.3 Approaches to understanding the problem

The nature of young people’s educational decision-making is complex and many approaches can and have been taken to understand their choices. In psychology, theorists have, for example, linked educational choices to individuals’ personality types (Costa, McCrae, & Holland, 1984; Head & Ramsden, 1990). In sociology, educational and vocational behaviour have been understood as products of socio-economic factors such as social class (Ball, Davies, David, & Reay, 2002; Bourdieu & Passeron, 1990). Less polarised approaches to academic motivation include self-efficacy theory (Bandura, 1997), intrinsic and extrinsic motivation (Ryan & Deci, 2000), interest development (Hidi & Renninger, 2006; Krapp, 2005), attribution theory (Weiner, 1985) and expectancy-value theory (Eccles et al., 1983).

1.4 The Eccles et al. expectancy-value model of achievement-related choices: a clarifying lens

The Eccles et al. (1983) expectancy-value model of achievement-related choices (see Figure 1) is comprehensive and based on empirical evidence. It is grounded in social psychology and incorporates social, psychological and cultural aspects that have been shown to affect young people’s motivational behaviour. Important components of the model are the expectations and values of individuals concerning their choices about participating in an activity. Eccles and her colleagues have developed and tested this
model over many years and in many studies (Eccles, 2009; Eccles et al., 1983; Eccles, Barber, & Jozefowicz, 1999; Meece, Wigfield, & Eccles, 1990; Nagy et al., 2008). The model has, for example, contributed to the understanding of how achievement is linked to interests and self-concepts in mathematics, language and science (Denissen, Zarrett, & Eccles, 2007), of college enrolment in mathematics and English (Eccles, Vida, & Barber, 2004), high school course enrolment in mathematics and science (Simpkins, Davis-Kean, & Eccles, 2006) and of links between interest and competence in sports (Fredricks & Eccles, 2002). A specific focus on gender is often seen, for example, in studies of women’s educational and occupational choices in relation to physical sciences, engineering and applied mathematics (Eccles, 1994; Eccles et al., 1999). The model is inclusive in the sense that many of its constructs overlap with concepts from other motivational theories. These include Bandura’s (1997) self-efficacy, Ryan and Deci’s (2000) intrinsic and extrinsic motivation and the concept of interest (Hidi & Renninger, 2006; Krapp, 2002, 2005). The link between these concepts and the Eccles et al. model is described by Eccles and Wigfield (2002).

Expectancy-value theory is a long-standing perspective on motivation (Wigfield & Eccles, 2000). The main idea is that ‘individuals’ choice, persistence, and performance can be explained by their beliefs about how well they will do on the activity and the extent to which they value the activity’ (p. 68). The motivation for an educational choice thus consists of two main aspects: the students’ expectation of success and the value the students attribute to this particular option. The Eccles et al. model

![Figure 1. Eccles et al. (2002) expectancy-value model of achievement-related choices. This article focuses most strongly on the concepts in the shaded boxes. Modified with permission from the Annual Review of Psychology, vol. 53. © by Annual Reviews, http://www.annualreviews.org](image-url)
predicts that expectation of success and subjective task value directly influence achievement-related choices. Subjective task value consists of interest-enjoyment value, attainment value, utility value and relative cost. The model assumes that expectation of success and subjective task value are positively related (Eccles & Wigfield, 2002), which implies that people tend to value what they believe they can do well and devalue what they do not master. People also expect a higher degree of success on tasks and subjects that have high value for them.

In the model, identity forms expectations and values and affects achievement-related choices, such as a career choice (Eccles, 2009). According to Eccles and colleagues, students’ personal identity includes self-image, values and goals and the identity they think they may hold in the future. Students’ social or collective identities are about how they see themselves in terms of social categories and how they express membership to these categories through symbols and activities. Gender identity has also been thoroughly addressed by Eccles and colleagues (Eccles, 1994, 2007, 2009; Eccles et al., 1999; Nagy et al., 2008). Culture defines gender and the stereotypes related to jobs, subjects and activities. Young people use these stereotypes as tools in their identity work. They have their own perceptions of each stereotype and they are influenced by parents, peers and other socialisers. The model contends that culture, through gender and gendered stereotypes, socialises young men and women differently. This suggests that they may develop different hierarchies of core personal values (Eccles, 2009; Eccles et al., 1999) and value activities and future goals differently, because gender tends to suggest which activities go with which identity.

A few issues should be given some consideration when using the Eccles et al. model in studies of young people’s STEM-related choices. These are not all necessarily limitations of the model, but features that may have implications for research questions, study design or interpretations of results. First, young people’s educational choices are likely to be shaped in various complex ways over time (Cleaves, 2005; Holmegaard, Ulriksen, & Madsen, 2010; Vaughan, 2005). It will be valuable to complement research that concerns young people’s expectations of success and subjective values at one point with qualitative in-depth and longitudinal studies to assess how expectations and subjective task values develop and affect choices over time. As illustrated by the dotted line in the model (see Figure 1), achievement-related choices and performance at one time affect later choices through the personal experiences they lead to. In addition, the cultural milieu that affects expectations and subjective task values (see Figure 1) is constantly changing. This can be a challenge if results obtained at one time are used to form, for example, recruitment initiatives after changes have occurred in the surrounding cultural milieu. However, this also offers explanations of how cultural changes may contribute to observed trends in STEM participation. For example, today’s strong focus on environment and climate change is likely to increase students’ interests in such issues, which according to the model may lead to increased enrolment in environment-related studies. Such an increase is observed in, for example, the US (Vincent, 2009), the UK (Blumhof & Holmes, 2008) and Norway (Norwegian Universities and Colleges Admission Service, 2007, 2010). Many countries also report increasing proportions of women among medical students and practitioners (Kilminster, Downes, Gough, Murdoch-Eaton, & Roberts, 2007), while engineering and physical sciences experience great gender imbalance (EU, 2009). Young women in general are more interested in health issues than technology (Tytler, Osborne, Williams, Tytler, & Clark, 2008). Also, a medical education and profession may be well suited
to a female gender identity, thus giving medical studies a high attainment value to many women. The Eccles et al. model then suggests that more women would choose medicine than engineering – which is consistent with the observation that while the proportion of women in higher education in general, and in medicine in particular, has increased considerably in the later decades, the physical sciences and engineering have not experienced a corresponding increase.

Some STEM researchers may argue that social structures related to ethnicity and class are understated in the Eccles et al. model. However, although class and ethnicity are not listed explicitly in the model in Figure 1, they are present as parts of individuals’ cultural milieu and their socialisers’ beliefs and behaviours. It should be kept in mind, however, that mechanisms involved in decision-making may vary across cultural settings and subgroups and that the model may need to be adjusted to fit conditions that differ significantly from the conditions in which it was developed (mainly the US), for example in developing countries.

Another issue is that expectancy-value theories like the Eccles et al. model have been criticised for assuming that people consider all options and that they have sufficient correct information on which to base decisions (Bandura, 1997). However, the term subjective task value implies that what matters is the individual’s subjective interpretation of, for example, what a science course has to offer. Similarly, in the model it is not the actual costs of the course that affect the choice to participate or not, but the costs individuals believe to be involved. This is true whether the individual is well-informed or has insufficient or even incorrect information.

Researchers should note that the components in the Eccles et al. model differ in character. While young people may evaluate the utility value of a study option by counting pros and cons, interest-enjoyment and attainment values are more related to emotions and affective experiences and may not be evaluated in a similar manner. Holmegaard, Ulriksen, and Madsen (2010) have studied the narratives young people create concerning their educational choices and describe how ‘the gut feeling’ is important in the pursuit of a ‘right choice’. This might seem to be at odds with the Eccles et al. model, which may at first sight appear to portray a well-ordered and maybe rational decision-making scheme. However, we hypothesise that the ‘gut feeling’ that students describe as important is likely to be composed of a number of components, for example, identity matching (Taconis & Kessels, 2009), affective as well as more rational subjective values and conscious or subconscious self-efficacy considerations. We believe that although these aspects are not fully articulated when students follow ‘the gut feeling’, the components in the Eccles et al. model may nonetheless be strongly present as explanatory factors for their choices.

Finally, the Eccles et al. model does not address the role that mere chance and coincidence may play in people’s educational choices. People sometimes state that their choice was largely coincidental (Schreiner, Henriksen, Sjaastad, Jensen, & Løken, 2010). They stumbled across a study, just happened to meet someone who inspired them or ended up with what was a more or less random fourth or fifth choice in their applications. These students may be among those who are less conscious of the process, as mentioned above. But it could be that a real part of the variance observed in young people’s STEM-related choices must be attributed to chance.

We believe that the Eccles et al. model offers several valuable insights to science and mathematics educators. It is comprehensive and founded on empirical evidence and this article will demonstrate that it is suitable as a tool to help structure and
interpret current research literature concerning young people’s attitudes to, and participation in, STEM. When the above mentioned issues are taken into consideration, it can also guide future research and suggest ways forward to increase participation in STEM. The model’s focus on both expectation of success and subjective task value is particularly pertinent. Expectations or efficacy-beliefs alone, though undoubtedly very influential, cannot fully explain young people’s educational choices. Other strengths are the model’s inclusion of social variables such as gender, cultural milieu and socialisers and its acknowledgement of the importance of identity.

1.5 The late-modern zeitgeist

The causes of participation problems in STEM subjects and careers are many and complex. Since the decline in participation is a phenomenon occurring in many highly developed countries, but seldom in developing countries, it is conceivable that explanations may be found in patterns and processes in social life related to level of societal development. Schreiner and Sjøberg (2007), arguing from a sociological perspective, point to the pre-eminence that highly developed societies give to the individual and claim that modern young people tend to evaluate STEM education in terms of its contribution to their self-development. This article therefore discusses some characteristics of the late-modern zeitgeist that may be relevant to understanding the STEM related educational choices made by young people.

Today’s highly developed societies have evolved through various characteristic eras: from hunting and gathering, to agrarian society, to industrial society and finally to the current era. The periods are characterised by particular cultural and social patterns. Social change is not only a change of economic foundations, principal industries and prevailing skills and professions, but also a matter of cultural perceptions, social patterns and ways of thinking and understanding about oneself, one’s surroundings, one’s future and the world.

Modernity and modernisation are terms connected to cultural, economic and political developments in developed societies throughout the last two hundred years at least. Modernity is associated with the era of industrialisation and this discussion will be restricted to the most recent decades of the post-war period. Many terms have been used to classify the present day post-industrial period, including high modernity, late-modernity, reflexive modernity (Giddens, 1991), second modernity (Beck, 1999), and liquid modernity (Bauman, 2001). This article uses the term late-modernity (sometimes shortened here to modernity). Giddens and Beck described late-modernity in the 1990s, but the period’s characteristic traits are recognised also in more recent work (Bauman, 2008; Furlong & Cartmel, 2007). Some theorists, for example Jean Baudrillard and Jean-François Lyotard, argue that we have passed from the modern epoch into a new condition of post-modernity (Giddens, 1991). A post-modern society is described as highly pluralistic and diverse, with no universal principles and no common ideas or grand narratives (a concept proposed by Lyotard) that can direct social development (Giddens, 1991). The post-modern conceptualisation of our society is contentious (Fornäs, 1995; Giddens, 2001) and many would argue that rather than an epochal shift, we are undergoing a continuation of modernity into a late and accelerated stage: an ultra- or super-modernity. The epoch is recognised by a radicalisation, amplification and intensification of modernity (Beck, Giddens, & Lash, 1994; Fornäs, 1995; Miles, 2000). This article will not engage with the technicalities of this debate, but rather frame young
peoples’ educational choices within generally accepted aspects of the theories concerning late-modern society.

Giddens describes the weakened roles of traditions and authorities in late-modern society (Beck et al., 1994). As people gain access to more information through media, education and other means, they develop an appreciation that so-called ‘facts’ can be temporary, incomplete and debatable. This leads people to question the credibility of the established traditions and ‘truths’ that are passed down from authorities and older generations. Consequently, authorities lose some trustworthiness and religious leaders, scientists, politicians, teachers and parents have a weakened function in guiding young people in their beliefs, choices and actions. According to Ziehe and Stubenrauch (1993), the breakdown of traditions has lead to cultural liberation of the individual. Cultural liberation means that the family background and the geographical background of the individual have less capacity to define a person’s identity in terms of class, social status, ethnicity, sexuality, profession, geographical association etc. The individual is less dependent on traditions, norms and handed-down interpretations of who they are. Identity is no longer perceived as something that is given, but as something one chooses and develops. Young people in late-modern societies tend to be more culturally, socially and geographically liberated than those in earlier generations. According to this view, young people in highly developed countries are largely free to choose their religion, social group, lifestyle values, education and profession.

These perspectives describe a late-modern notion of free choice. Nevertheless, the idea is challenged by some sociologists and by empirical studies that point towards a still very pronounced social reproduction. Young people may have the impression that they have an almost infinite number of options and degrees of freedom, but youth studies find that the home background of young people will still influence their dispositions related to lifestyle, values and educational choices (Atkinson, 2008; Bourdieu, 1984, 1990; Furlong & Cartmel, 1997; Heggen, 2004; Krange, 2004; Turmo, 2003). This means that in reality, they may not make their life choices as freely as it might seem to them. However, their idea that they choose freely makes these perspectives highly relevant for understanding their educational and career choices.

2. Looking at young people’s relationship to STEM subjects and careers through the lens of the Eccles et al. model

The research literature from science and mathematics education presented in this section is discussed in terms of the two constructs within the model that directly influence achievement-related choices: the subjective value of the school subject or university course for the individual and the expectation of success in the subject or study. The discussion is structured around each of the four components of subjective value shown in Figure 1: interest-enjoyment value; attainment value; utility value; and relative cost, followed by a fifth section concerning students’ expectation of success. For each component, three different aspects are considered: young people and STEM subjects and careers; young women and STEM subjects and careers; and how STEM choices can be understood in the context of the late-modern zeitgeist. The description of the components in the Eccles et al. model is based on various texts (Eccles, 1994; Eccles et al., 1983, 1999; Eccles & Wigfield, 2002; Wigfield & Eccles, 2000).
2.1 Interest-enjoyment value

Interest-enjoyment value concerns how interested individuals are in the subject in question and the enjoyment they will feel when participating in it. Take, for example, the choice between two subjects in upper secondary school: advanced mathematics and economics. Students who are, for example, political activists are possibly quite interested in community economics. They may therefore enjoy economics and statistics more than calculus and an economics course will have higher interest-enjoyment value for them than advanced mathematics. Interest-enjoyment value corresponds to intrinsic motivation (Ryan & Deci, 2000), Shernoff, Csikszentmihalyi, Schneider, and Shernoff’s (2003) flow and interest as described by Hidi and Renninger (2006), Krapp (2002) and Schiefele (1999).

2.1.1 The interest-enjoyment value of STEM subjects and careers for young people

Interest in, and enjoyment of, the subject were among the most frequently stated reasons for educational choice among all groups of respondents in the Future Track survey (Purcell et al., 2008), a large-scale, longitudinal survey following students from application to higher education until they get their first job. Some claim that interest in school science among young people in developed countries is low (OECD, 2008; Osborne, 2008; Tytler, 2007) and that it tends to decrease as students progress through school (Osborne, Simon, & Collins, 2003). Liking of mathematics has also been found to decline throughout school (Fredricks & Eccles, 2002; Wigfield, Eccles, Iver, Reuman, & Midgley, 1991). It is worth noting that interest in the topics per se may be a quite different matter from interest in school science and mathematics as experienced in the classroom. For instance, Häussler and Hoffmann (2000) distinguished between interest in the physics content and interest in aspects of school physics. They found that students’ interest in physics as a school subject was less related to their interest in physics than to the students’ self-esteem as being good achievers. Thus, for school physics, it appears that interest and expectation of success are positively related, in line with Eccles and Wigfield’s (2002) claim. Lyons and Quinn (2010) found that declining science enrolments among Australian Year 11 students were likely to be due to school science’s failure to engage students, but unlikely to be due to a decline in general interest in science among today’s young people. There are also indications of a relatively high interest for science and technology topics in European populations in general (EU, 2005). The 2006 PISA study found that more than 90% of 15-year-old students appreciated science in general and supported scientific enquiry, but only 57% agreed that science is very relevant for them personally. The students also reported high levels of interest in the science topics examined by the PISA test, but only a minority saw themselves doing science in the future (OECD, 2007a).

Köller, Baumert, and Schnabel (2001) found that mathematics interest among German 10th graders affected both the likelihood of choosing an advanced mathematics course and their achievement in upper-secondary mathematics. The science education literature indicates that school science is often delivered in a conventional way, which is very similar across countries (Angell, Guttersrud, Henriksen, & Isnes, 2004; Carlone, 2003; Lyons, 2006) and includes transmissive pedagogy, unengaging curricular content and is, in the case of physics and chemistry, associated with difficulty. One topic that seems to engage young people is astronomy (Angell et al., 2004;
Angell et al. (2004) also reported that physics students found the more ‘exotic’ topics like relativity and quantum physics more appealing than applications-rich topics related to everyday life, like electricity or friction. Regarding relativity, students (especially males) enjoyed the intriguing implications of the theory and they (especially females) enjoyed having ‘expertise’ in a topic that sometimes emerged during everyday conversations. This social element of physics knowledge appeared especially important among women and helped them relate physics to the ‘everyday world’. Along similar lines, Osborne and Collins (2001) found that British 16-year-olds (especially girls) emphasised the importance of science for explaining things to other people. Stokking (2000) found that most physics students in the Netherlands would like a stronger orientation of the subject towards the phenomena of daily life and of the instructional approaches towards active participation. Labudde, Herzog, Neuenschwander, Violi, and Gerber (2000) suggested that such changes would be effective for improving girls’ experiences of physics and therefore might increase their likelihood of choosing a science career. However, the Relevance of Science Education (ROSE) survey investigated 15-year-olds’ interests in science in a range of countries and found that not all everyday contexts enhance interest. Neither girls nor boys are much interested in the weather, the sunset, how mountains and rivers develop and change, botany and farming, the work and life of scientists and how scientific knowledge develops, or in general everyday matters such as detergents and soaps, plants in the local area and how food is produced and conserved (Schreiner, 2006).

In short, school science appears to be unable to meet the students’ personal interest in science-related topics. Lyons (2006) remarked that negative school science experiences may be a significant influence on students’ enrolment deliberations and, moreover, that school science for many students appears to offer few intrinsic incentives to continue. Barnby, Kind, and Jones (2008) found that as British students progressed through lower-secondary school, their experiences of science were more and increasingly related to school science and less to science in informal contexts. They suggested that it is therefore particularly important that in order to stimulate interest in pursuing science, school science needs to be an enjoyable experience for students. Braund and Reiss (2006) call for more out-of-school science learning, such as field trips, science centres and science museums. Häussler and Hoffmann (2000) claimed that physics as it is taught in the majority of physics courses does not take into account students’ interests and found that an interest-driven and context-rich physics curriculum was superior to the traditional physics curriculum and that it also resulted in an improved physics-related self-concept, particularly among girls.

2.1.2 The interest-enjoyment value of STEM subjects and careers for young women

A number of interest studies in science education show that girls’ and boys’ interests are different (Cerini, Murray, & Reiss, 2003; Osborne & Collins, 2001; Scantlebury & Baker, 2007). On a general level, girls express stronger interest in issues to do with human health and well-being, whereas boys are more interested in things to do with, for example, technology and physics. Girls also appear to be generally less engaged by science (Tytler et al., 2008). One likely reason why boys develop stronger interests in science than girls (particularly in the physical sciences) is that they have more childhood experiences involving science and technology (Hazar, Sadler, & Tai, 2008;
Jones, Howe, & Rua, 2000; Sjøberg, 2000). Also, the decline in students’ attitudes during secondary years has been found to be especially pronounced for girls (Barmby et al., 2008).

The ROSE study found that the interests of girls differed markedly from those of boys in most countries. Whereas boys favoured ‘dramatic’ topics like explosions and technology, girls were more interested in how to take care of the body, how to care for animals and why we dream at night and in aesthetic topics like the rainbow or questions about the paranormal (Schreiner, 2006). There appears to be a tendency for boys to be concerned with the subject itself, whereas girls are interested in topics which may help them in their relations with themselves and other people. The preoccupation among young women with using their scientific insight in social settings was also noted by Angell et al. (2004) for physics students.

2.1.3 Interest-enjoyment value and the late-modern zeitgeist

Beck and Beck-Gernsheim (2002) contend that:

We live in an age in which the social order of national state, class, ethnicity and the traditional family is in decline. The ethic of individual self-fulfilment and achievement is the most powerful current in modern society. (p. 22)

Young people in late-modern societies wish to develop their abilities, to fulfil themselves and to live their lives to the fullest potential. As the existential meaning of life is to a lesser extent defined by religion or traditions, every person has to interpret this meaning for themselves (Furlong & Cartmel, 1997). To understand the culture of self-realisation, one may draw on classical psychological theories proposing that as some needs are satisfied, new and more sophisticated needs appear. The idea behind Abraham Maslow’s (1968) hierarchy of needs is that humans are by nature searching creatures. Our needs will never be satiated, because as soon as one need is satisfied, we seek to satisfy other needs. The basic needs at the bottom of the pyramid are of a physiological character (to breathe, eat, sleep etc.), while at the top lies the need for self-realisation. With an increasing level of modernisation and social welfare comes greater emphasis on subjective well-being, such as friends, leisure, good health, life satisfaction, ecology and free choice (Inglehart, 1997).

These perspectives are relevant for school and education, since educational institutions are seen as arenas for self-realisation and of fulfilling and developing personal talents and abilities. Late-modern young people see their interests, their school subjects, their job plans, their friends and their views (on physics, mathematics and everything else) as part of their identity, of who they are (Beck, 1999; Giddens, 1991; Goffman, 1959). They wish to be occupied with something they can throw themselves into – something exciting and enriching. The discourse of the late-modern era is characterised by words like urge, desire and pleasure rather than patience, hard-work and obedience. Students also expect passion and enjoyment in the learning situation, while monotony and tediousness are ill suited to their identity. Independence, flexibility, communication and creativity are key words describing their future job expectations (Illeris, Katznelson, Simonsen, & Ulriksen, 2002; Schreiner et al., 2010; Ulriksen, 2003). An empirical study of Danish students’ explanation for their educational choices found that the majority chose their subjects for ‘existential individualistic’ reasons – they wished to ‘develop themselves’, ‘get wiser’ and ‘become deeply
absorbed’ (Simonsen & Ulriksen, 1998). Especially among young women, there is a pronounced emphasis on self-realisation, while young men are more inclined to accentuate issues related to material standards and achievements (Sjödin, 2001).

2.2 Attainment value

Attainment value refers to how well a subject or course fits with a person’s identity. People want to confirm central aspects of their identity and tend to place higher value on subjects that allow them to do so (Eccles, 2009). Eccles and colleagues draw on theories about self-concept and identity (see Markus & Wurf, 1987) to clarify this aspect of attainment value. Also part of attainment value is the importance of fulfilling personal needs through succeeding (Eccles, 1994). Success can make people feel happy and proud of themselves and it can be stimulating to overcome challenges. Identity – or the self – motivates the individual for action (Markus & Wurf, 1987). Individuals pondering whether or not to choose a STEM course may be motivated by imagining the possible selves that have completed this course. For instance, someone who wants to express high intelligence as part of their identity may see an advanced mathematics course as having higher attainment value than an economics course, since the former is generally considered to be the more difficult. Of two possible selves, the advanced mathematics self is more consistent with the desired intelligent self than the economics self. Similarly it may be important to avoid subjects that are in conflict with a desired identity. If physics is perceived to be for ‘brainy’ and unpopular geeks, physics will have low attainment value for someone rejecting such an identity.

2.2.1 The attainment value of STEM subjects and careers for young people

Attainment value is closely linked to whether a person can identify positively with individuals associated with that subject area or profession. Literature from a range of countries has addressed the question of whether students see STEM subjects as worth pursuing and professionals in STEM fields as people with whom they can identify. Jenkins and Nelson (2005) and Bennett and Hogarth (2009) both reported that UK lower-secondary students expressed a sense of science being important in general terms, although not having much appeal for individual students. Many students see school science as uninteresting and irrelevant to their lives (Tytler et al., 2008), as authoritarian and abstract and with little room for search for personal meaning (Sjöberg, 2002). In a combined English and American study, students reported that they found mathematics rigid, inflexible and a subject that leaves no room for negotiation of meaning. Moreover, they did not see success in mathematics as relevant to their identity development except in that it offered access to future education and careers (Boaler, William, & Zevenbergen, 2000). Masnick, Valenti, Cox, and Osman (2010) found that American high school and college students considered scientific professions to be less creative and less people-oriented than other popular career choices. A large scale Australian study found that the most common reason given by 15-year-old students for not choosing any senior science courses was that they could not picture themselves as scientists (Lyons & Quinn, 2010).

Hannover and Kessels (2004) and Taconis and Kessels (2009) used self-to-prototype matching theory to investigate Dutch and German 9th grade students’ self-image and found that the students saw typical peers who preferred science subjects as being less attractive, creative and socially competent, but more intelligent and motivated,
than peers who preferred foreign languages or economics. Thus, their image of the
typical science student was that of a hard-working and intelligent, but rather boring
and socially awkward person. Perhaps not surprisingly, most of the students in the
survey saw themselves as less similar to the science prototype and more similar to the
humanities prototype. Lapan, Shaughnessy, and Boggs (1996) found that US students
who described themselves as extroverted were less likely to take additional mathematics
classes in high school. Aikenhead (2006) states that ‘a school science identity or a
good student identity may prove disastrous to students whose peers find their identities
socially unacceptable (‘It’s not cool’), causing these students to be unwilling to
engage even in science discourse’ (p. 118).

Recently, science and mathematics educators have called for more attention to be
given to the role that identity development plays in young people’s orientations
towards science and mathematics in school (Aikenhead, 2006; Osborne et al., 2009;
Schreiner, 2006; Sfard & Prusak, 2005) and to the societal changes going on in most
developed countries (Tytler, 2007). Brickhouse and colleagues have studied how
girls’ identities are influenced by school science (Brickhouse, Lowery, & Schultz,
2000; Brickhouse, 2001) and argue that identity formation is essential to understand-
ing science learning (Brickhouse, 2001). Kozoll and Osborne (2004) propose that a
student’s identity in science needs to be seen as part of their life world, of who they
are and what they want to become. Archer and colleagues (2010) describe how a
science identity appeared unintelligible for some young people in their study due to
its dominant gender, race and class configuration. Hazari, Sonnert, Sadler, and
Shanahan (2010) found that high school physics identities predicted physics career
choice. Archer, Hollingworth, and Halsall (2007) linked young working-class
students’ urban identities to a resistance to higher education. However, there are
students who are attracted to STEM subjects because of the traditional characteristics
associated with them. Carlone (2004) studied girls’ engagement in a physics class-
room that focused on real-world physics applications, such as in sports and medicine.
She discovered that some girls resisted the non-traditional meanings of science and
scientists if they saw them as threatening to their ‘good student’ identities. In any
case, it appears that students picture only a narrow range of STEM identities and, as
Cleaves (2005) concluded, having a hazy picture of what a future science self would
look like is not conducive to choosing further studies in science.

2.2.2 The attainment value of STEM subjects and careers for young women

Identities connected with some STEM subjects or courses are unattractive to many
young women in particular. Eccles (2009) claims that attainment value is especially
important when considering the impact gender has on the value students attach to a
wide range of occupational options. We suggest that it is even more crucial in the case
decisions about STEM subjects. Aikenhead (2006) states that ‘coming to appreciate
science requires an identity shift whereby students come to consider themselves as
science friendly’ (p. 117) and many careers in STEM are connected to gendered
stereotypes. This suggests that young men and women attach quite different values to
the identities associated with such careers. In her study of subject choices among
young Americans, Eccles (2009) found that placing a high value on helping other
people was a predictor for not choosing careers related to physical science or business
and law. She also found that girls were less likely to enrol in advanced mathematics,
primarily because they found it less important, less useful and less enjoyable than did
boys. The study by Lyons and Quinn (2010) found that Australian girls were significantly more likely than boys to attribute decisions not to take science to being unable to picture themselves as scientists. The authors recommend that efforts be made to better inform girls about the range of possibilities available to women in science careers.

Research has also identified that young women in science often lack role models (Miller, Blessing, & Schwartz, 2006; Osborne et al., 2009), though Hazari et al. (2010) and others note that the effect of role models on young people’s educational choices appears hard to document.

Buck, Clark, Leslie-Pelecky, Lu, and Cerda-Lizarraga (2008) found that girls’ processes in identifying a role model involved personal connections and that their initial image of a scientist led them to believe they could not have such a connection with a scientist. What does appear to have an effect is personal connections with mentors or ‘significant others’ who know the adolescents and is willing to help them clarify their goals, personal strengths and interests (Sjaastad, 2010). Aschbacher, Li, and Roth (2010) also point to the effect students’ ‘socialisers’ (e.g. teachers, parents and peers) have on their science identity and persistence in science. Baker and Leary (1995) found that ‘the girls with the strongest commitment to scientific careers learned to love science through the love of a parent or grandparent involved in science’ (p. 25). Hasse, Sinding, and Trentemoller (2008) found that a majority of Danish female physicists in their sample had been inspired to pursue a physics career by their father.

Blickenstaff (2005) points to the lack of role models as one possible reason for women’s under-representation in STEM, together with a science classroom pedagogy that favours male students and an inherently masculine scientific epistemology. He claims that biology and life sciences are at the feminine end of the spectrum of sciences, with physics and engineering at the masculine end. Johnson (2007) found that minority group women were discouraged by science classes that presented science as decontextualised and gender-, ethnicity- and race-neutral. In the words of Osborne et al. (2009), ‘both the context, purpose and implications matter for girls and any attempt to present a decontextualised, value-free notion of science will reduce their engagement’ (p. 6).

2.2.3 Attainment value and the late-modern zeitgeist

Constructing and developing one’s identity is, according to Illeris et al. (2002), at the heart of late-modern youth culture:

… And precisely this identity development can be seen as the essence or the driving force behind all the choices that young people today are plunged into, as the very central task of youth today. (p. 26, our translation)

These authors argue that the traditional question ‘What do you want to be when you grow up?’ now addresses a more far-reaching issue than in previous generations. Today, the answer to this question should be seen less as a perception about a job or an income and more as an answer to the question ‘Who do you want to be when you grow up?’ (Illeris et al., 2002, p. 57, authors’ emphasis, our translation). When young people choose an education or job, they simultaneously express important components of their identity. Education is seen as a means for self-actualisation and for fulfilling and developing personal talents and abilities. Young people wish to find a study they
can be passionate about, something exciting and enriching (Illeris et al., 2002; Simonsen & Ulriksen, 1998; Ulriksen, 2003). The processes characterising human development in highly developed societies imply that society accentuates the individual’s freedom and independence. From the cultural liberation of the individual it follows that one’s identity is no longer perceived as something that is handed out or given, but, rather, as something one has to choose and develop by oneself (Côté, 1996; Giddens, 1991). It is up to each person to decide who one wants to be and in what way and direction one will develop oneself and one’s life.

Across all epochs and cultures, the youth phase is commonly seen as a period in one’s life that is particularly occupied with identity construction (Coleman & Hendry, 1999). Even though a person’s identity is a relatively stable perception of ‘who’ one is, it is in continuous development. In the light of new knowledge and new experiences, people constantly reconsider and redevelop their self (Giddens, 1991). The US sociologist Erving Goffman sees social life as performances with agreed rules for behaviour. Based on his empirical analyses of human interaction, Goffman (1959) describes how every facet of people’s public choices and behaviour, such as language, actions, values and beliefs, are tacit symbols or codes of social identities. Choices are continuously made and remade on everyday matters, such as clothing, physical appearance, leisure activities, taste in music, sports, sexuality and beliefs (Giddens, 1991). Signs of what one is not, are just as important as signs of what one is (Frønes, 1998). Also in the school and classroom context, young people define and express their identities through signs such as attainment, subject preferences, classroom and playground behaviour. All these signs can be seen as indicators of one’s identity (Lyng, 2004).

2.3 Utility value

Utility value concerns how helpful an educational choice is in reaching other goals, such as career goals. Advanced mathematics often gives more credits than economics in applications to universities, which may give it higher utility value for some students. More short-term goals also include some utility value, for instance wanting to take the same course as a friend. Options that have utility value are extrinsically motivated (Ryan & Deci, 2000). Extrinsic motivation causes people to engage in activities to obtain a separate outcome. Physics may have high utility value for students who want to be admitted to medical studies, even if they have no interest in the subject.

2.3.1 The utility value of STEM subjects and careers for young people

Upper secondary STEM subjects often have a ‘gate keeping’ function for entry into prestigious higher education programmes such as medicine and engineering science. Some school systems also reward students with extra credits for STEM subjects. These subjects may therefore have utility value for many reasons: they can serve as qualifications for specific plans for higher education; they can raise a student’s general qualification level for university admission; and they can help in keeping many options open as long as possible. It is therefore not surprising that utility for future careers often emerges as an important reason for choosing these subjects in upper secondary school (Angell et al., 2004; Hutchinson et al., 2009; Lie, Angell, & Rohatgi, 2010; Lyons, 2006; Miller et al., 2006; Osborne & Collins, 2001). In their study of Year 13 students in New Zealand, Hipkins and Bolstad (2006) found that many
students stayed in science to keep their options open. Similarly, Bøe (submitted) found that many Norwegian students chose upper secondary science for its utility for university admission. However, in school systems where students are given a total score based on their average marks regardless of subjects, some may avoid STEM subjects since they are considered difficult and may bring down their total average (OECD, 2008). Lyons and Quinn (2010) argue that the removal or weakening of extrinsic rewards traditionally given by Australian universities has contributed to lower participation in physical science subjects in schools.

In higher education, choosing a STEM field programme for its utility value would mean choosing it because it offers some kind of benefit apart from the intrinsic value or attainment value of the STEM course itself. A STEM course could, for example, be regarded as the best way to a secure job or a high income or as necessary in order to get a job in a dynamic environment or with benefits such as travel. In most developed societies, however, STEM education programmes are unlikely to be regarded as an ‘easy’ way to good jobs or other benefits, because of their perceived high cost (see below). Moreover, for the majority of STEM-educated professionals, the prospects for high salaries are not much greater than for most other higher education courses of the same length and certainly lower than for professions within finance and commerce. In a recent study of Norwegian first-year university STEM and non-STEM students (Schreiner et al., 2010) the respondents rated a range of aspects of a future profession on a 4-point scale from ‘not important’ to ‘very important’. It appeared that most students in all education courses rated aspects relating to self-development highest, whereas utility values such as salary and job safety were rated somewhat lower.

2.3.2 The utility value of STEM subjects and careers for young women

In many countries, young women are more likely than young men to attend higher performing, academically oriented tracks and schools (OECD, 2007a). This gives reason to suspect that young women make more instrumental educational choices than young men and therefore rely more heavily on the utility value of post-compulsory STEM subjects. Miller and colleagues (2006) found that girls often planned science majors mainly because they needed it to enter health professions such as medicine. In a UK study, Bennett and Hogarth (2009) saw that among students who viewed chemistry positively, more girls than boys did so for career reasons. They pointed out that ‘subject “hardness” is more likely to be tolerated if it has the potential utility for future jobs’ (Bennett and Hogarth, 2009, p. 1987). Hazari et al. (2010) use the term ‘outcome expectations’ for values that students seek in a future occupation, such as high wages, people-oriented work etc. and they point out that there are great gender differences in these values. In their US study, boys were more inclined than girls to want jobs where they control others, jobs that are easy, make them famous and give them high pay and status. On the other hand, girls were more inclined than boys to want to help others. Thus, given the image of science and scientists described above, young women are less likely than men to see many STEM career paths as the best way to reach their goals.

2.3.3 Utility value and the late-modern zeitgeist

Building a late-modern identity is a reflexive project. It happens in constant negotiation with a rapidly changing society, filled to the brim with information, choices and trends (Giddens, 1991). To ensure that educational choices fit this project, young
people are likely to want a lot of helpful information and as many open options as possible. Upper-secondary STEM subjects are useful in this sense, because they often award students extra credit and qualifications that make them eligible for many different university studies. Choosing not to continue with post-secondary STEM subjects may have an opposite effect, closing doors to further studies in many fields. Late-modern young people are likely to find utility value in subjects that help their identity project, for example by ensuring admission to a university study they believe to be interesting and self-realising or by keeping all options open until the interesting and self-realising career choice reveals itself. One may also expect late-modern young people to value educational choices that lead to secure and well-paid jobs. Such jobs allow for subjective well-being, which is emphasised in modern societies (Inglehart, 1997) and may function as a safety-net against modern risks such as unemployment in an unpredictable global market (Beck, 1999). The persistent calls for more people in STEM suggest that a STEM career is a safe choice. However, the large costs that come with the choice, in terms of difficulty and number of years of study, make it unlikely that young people seeking a fast track to well-paid, secure jobs will choose STEM over other career paths that offer faster ways to a high salary. It is also possible that stereotypes associated with people who choose STEM subjects and careers, alienate students who not only want a secure, well-paid job, but also a good social work environment (Institution of Engineering and Technology [IET], 2008).

2.4 Relative cost
Relative cost refers to the negative aspects of one educational choice relative to other options. It could, for example, be the time and effort that is required to do well in advanced mathematics compared to economics. It could be the fear of failing advanced mathematics or the fear of disappointing one’s parents. Relative cost also includes lost opportunities from choosing one subject over another or having to put up with negative stereotypes associated with a subject or profession.

2.4.1 The relative cost of STEM subjects and careers for young people
Physical science and mathematics subjects on all levels are generally perceived to have higher costs than most other subjects. This is largely related to their reputation as being difficult and work-intensive (see subsection on expectation of success). For students who choose STEM subjects in upper-secondary school primarily for utility reasons (to get into medical school, for instance), the cost may also be considerable in terms of having to put up with subject matter they find uninteresting, unattractive and ill matched to their identities. For some students, science and mathematics subjects also carry costs in terms of maths anxiety that may affect choices and performance (Ashcraft, 2002; Hembree, 1990). However, choosing these subjects tends to reduce the potential costs of lost opportunities due to ‘wrong’ choices, since they keep many options open for further studies (see discussion under utility value).

2.4.2 The relative cost of STEM subjects and careers for young women
Young women appear to perceive the costs of pursuing STEM careers to be particularly high (Angell et al., 2004; Carlone, 2003; Frome, Alfeld, Eccles, & Barber, 2006;
OECD, 2008; Warrington & Younger, 2000). It may be that girls are generally more afraid than boys of failing in STEM subjects and courses. For example, Norwegian girls who have chosen upper-secondary science worry more than boys about not being clever enough to master the subjects (Bøe, 2009). Girls are also often in the minority in physics or advanced mathematics classrooms, a circumstance which some of them would regard as a cost. In addition, the pedagogy in many science classes has been found to favour male students and to use inherently masculine scientific epistemology (Blickenstaff, 2005), which involves extra costs for girls.

2.4.3 Relative cost and the late-modern zeitgeist

The theory of the global risk society was proposed by Beck (1999), who sees risks as unforeseeable future accidents or disasters caused by present-day choices. These are among the unpleasant outcomes of modernisation. In the context of environmental problems, Beck describes how social and technological development, along with globalisation, has led to unpredicted and unintended side-effects. This theory of the risk society was developed further, to include the personal lifeworld of the individual (Beck & Beck-Gernsheim, 2002). For example, people in late-modern societies are aware that by choosing an education, a career, a partner, a hobby or a lifestyle, one exposes oneself to risks. Things can go awry and the choice may turn out to be the wrong one. The choices one makes may be perceived to be critical or even fatal. In some contexts, educational failure, unemployment and poverty may all be regarded as the result of wrong choices. Consequently, people’s actions and choices may be guided by risk evaluations and by steering clear of danger.

Late-modern young people can benefit from the opportunity to form lives which correspond with their interests and values. But this freedom carries some challenges, since traditions and norms have to some extent functioned as safe and supporting frameworks. Cultural liberation creates freedom to choose, but also the obligation to choose and young people must make their choices with less guidance from traditions and authorities. Furthermore, when they have made their choices, they are themselves responsible for the outcome, they have only themselves to blame and must themselves handle the consequences if something goes wrong (Furlong & Cartmel, 1997). For example, an educational choice represents risks, as it may lead to drop-out or failure by not fulfilling expectations or by being too demanding and hard to get through. Modern young people tend not to explain this unhappy situation in terms of religion, destiny, nature, inheritance, limitations of social class or lack of options, but by their personal failure. The late-modern notion of free choice gives them the full responsibility, even if their problems are actually rooted in social constraints (Furlong & Cartmel, 2007). Young people in Beck and Beck-Gernsheim’s (2002) individualised risk society are likely to negotiate their educational choices against the risks and other relative costs they entail.

2.5 Expectation of success

Students presented with various educational options will evaluate their chances of succeeding with each of them. For example, what students see as success in advanced mathematics and economics depends on their self-images in mathematics and economics. Achieving a mark just above average in mathematics may be seen as a
success if they see themselves as average mathematics students, but a failure if they consider themselves to be very good mathematics students. Expectation of success also includes the students’ estimations of how difficult the subjects are. If they regard advanced mathematics as more difficult than economics, they may characterise a slightly above average mark in advanced mathematics as a big success, while an equal level of success in economics would require a top mark. Eccles and Wigfield (2002) define expectation of success as ‘individuals’ beliefs about how well they will do on upcoming tasks’ (p. 119). They distinguish between expectation of success in specific upcoming tasks and beliefs about abilities in broader fields. However, they have found that children and adolescents do not distinguish between these two and that the two concepts cannot be empirically separated (Eccles & Wigfield, 2002). They also state that expectation of success is measured in a manner similar to Bandura’s self-efficacy beliefs (see, e.g., Bandura, 1997; Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Eccles (1994) argues that people’s hierarchies of efficacy in different subjects matter more than the actual level of efficacy. The crucial point is not, for instance, whether girls feel as efficacious in mathematics as boys, but whether or not girls and boys feel less efficacious in mathematics than in other subjects.

### 2.5.1 Young people’s expectation of success in STEM subjects and careers

Physical science and mathematics subjects have a reputation as particularly difficult and demanding (Angell et al., 2004; Carlone, 2003; Osborne & Collins, 2001; Tytler et al., 2008), which alone is likely to reduce students’ expectation of success in these subjects. Indeed, even gifted students and students who are high achievers in science subjects have been found to have lower expectation of success in these subjects than in most others (Lyons, 2006). Bennett and Hogarth (2009) found that physics was seen as hard – students felt they could get better marks in another subject. There is evidence to indicate that it is in fact more difficult for students to achieve high marks in the physical sciences than in other subjects (Coe, Searle, Barmby, Jones, & Higgins, 2008). This may have a negative effect on participation in STEM subjects, since an early sense of mastery (or lack thereof) shapes expectations of success (Eccles & Wigfield, 2002). For example, Shapka, Domene, and Keating (2008) found that early mathematics achievement works as a filter for Canadian students’ educational and occupational aspirations. Students’ self-perception and expectation of success in mathematics and science are also shaped by parents and teachers, who thereby also influence future educational choices (Hazari et al., 2010).

### 2.5.2 Young women’s expectation of success in STEM subjects and careers

Young women have been found to have lower self-efficacy in science and mathematics than young men (Barnes, McInerney, & Marsh, 2005; Cavallo, Rozman, & Potter, 2004; Lloyd, Walsh, & Yailagh, 2005; Lyons, 2006; Preckel, Goetz, Pekrun, & Kleine, 2008; Simpkins et al., 2006) and low expectation of success appears to reduce their willingness to choose STEM subjects and STEM careers in particular. In their study of American college students, Lapan, Shaughnessy, and Boggis (1996) found that girls had less faith than boys that they could perform mathematics and science tasks successfully and they expressed less vocational interest in mathematics than boys did. Häussler and Hoffmann (2000) found that for German students, boys’ physics-related self-concept was higher than their general school-related self-concept,
whereas the opposite was true for girls. The Future Track survey report describes a ‘confidence gap’ amongst first year university students: women rate themselves lower than men in numeracy and computer literacy (Purcell et al., 2008).

Zeldin, Britner, and Pajares (2008) and Zeldin and Pajares (2000) found differences in the ways young women and men develop their self-efficacy related to science and mathematics education and STEM careers. Whereas men’s self-efficacy arises most strongly from actual (perceived) achievement in tasks, women rely more heavily on interaction with others to build their self-efficacy. There are also stereotype threats related to girls’ and women’s abilities in some STEM areas. In a US study of how stereotype threats interfere with women’s performance on a mathematics test, Quinn and Spencer (2001) found that women performed better if the stereotype threat was reduced, that is, if they were told that men and women have proved to score equally well on the test. However, Dar-Nimrod and Heine (2006) showed that the stereotype threat had much less influence if the stereotype was presented as a result of different experiences rather than genetics. Also worth noting in this context is that girls appear to have other criteria than do boys for feeling that they understand the subject matter. Girls tend to believe they understand a concept only if they can put it into a broader world view, whereas boys appear to view physic concepts as valuable in themselves and are satisfied if there is internal coherence among the physics concepts learned (Stadler, Duit, & Benke, 2000). Osborne and Collins (2001) found that girls expressed a desire to know why things happened in science rather than learning only what happened. This adds to the impression that many girls feel alienated by decontextualised presentations of science (Osborne et al., 2009).

2.5.3 Expectation of success and the late-modern zeitgeist

Individualisation means that each person has a unique character with special potentials that may or may not be fulfilled (Frønes & Brusdal, 2001). Young people in late-modern societies wish to develop their abilities, to fulfil themselves and to live their lives to the fullest potential. What they regard as their abilities and potential will influence their expectation of success in various activities. Their need to live up to their abilities and realise their potential, makes expectation of success particularly important. Young people’s expectation of success in STEM subjects is challenged by the subjects’ reputation as particularly difficult and demanding, which causes some students to shy away from these subjects. For late-modern students, who feel responsible for the outcome of their free choices (Furlong & Cartmel, 1997), it may therefore be difficult to develop an expectation of success that is strong enough to outweigh the potential costs related to a failure and lost opportunities.

3. Conclusions and implications

This article has reviewed evidence that young people’s interest in school science and mathematics is relatively low and tends to decline as they progress through school. The subjects are often characterised as having transmissive pedagogy and unengaging, decontextualised content. For science, however, the disenchantment is greatest with school science. Students often show more interest in science topics per se. Students also regard science and mathematics as important in general, but less so for them personally. They struggle to identify with STEM culture and with STEM professionals and often find them ill suited to their identity. Many students tend to
choose post-compulsory STEM subjects for instrumental reasons: for example to gain admission to a preferred university or to keep their options open. Promises of a good job market and high salaries also motivate STEM choice, but STEM subjects and studies do not appear to offer the easiest paths to money and job security due to their reputation as being costly in terms of difficulty and work load. This perception of difficulty also affects students’ expectation of success in these subjects, which is generally lower than their expectation of success in other school subjects.

The literature also revealed gender differences in young people’s considerations within all the important elements of the Eccles et al. model. Girls tend to have a lower expectation of success and perceive a higher cost associated with studying science and mathematics. They identify less closely than boys with the disciplines and the professionals associated with these subjects and have different interests and different expectations for their understanding within the subjects. Finally, girls are less inclined to regard STEM as a means of attaining extrinsic goals and expectations than are boys.

3.1 Implications for improving participation in STEM subjects and careers

This article has demonstrated that the model developed by Eccles et al. provides a very useful lens through which to examine, structure and interpret the research literature concerning young people’s relationships to and decisions about science and mathematics. The perspectives gained from this process, aided by valuable contributions from sociological theories of late-modernity, constitute a strong evidence-based foundation for considering STEM participation issues. The following discussion suggests how students’ expectations of success and the interest-enjoyment value, attainment value and utility value of STEM subjects and studies may be increased, and their perceived costs reduced, in order to reduce the impediments to increased participation in STEM subjects and careers.

3.1.1 Interest-enjoyment value

There is evidently a challenge in keeping students interested in school science and mathematics as they progress through school and approach decision points about post-compulsory participation. The common characterisation of school science and mathematics pedagogy as dull, decontextualised and transmissive are especially alarming, considering that interest and personal relevance are very important for late-modern young people. Teaching styles and textbooks that try to counteract this impression may be helpful in this respect, for example by taking advantage of the interest students have in science topics, which appears to be higher than their interest in traditional school science. The literature also suggests that interest and enjoyment in STEM subjects can be increased if subject matter is more closely linked to science in society contexts and to activities that actually reflect the way STEM professionals work. The tendency for girls to be less interested in science than boys and for girls and boys to be interested in different topics and contexts cannot be overlooked. Relating subject matter to social issues of current interest may be especially beneficial for girls, who to a greater extent than boys want their scientific insight to benefit themselves and other people. For example, they may find STEM subjects more interesting if the applications for these subjects to health care and environmental concerns were more apparent to them.
3.1.2 Attainment value

To be more attractive to contemporary young people, STEM subjects and studies must be taught and presented in a way that acknowledges their identities. The literature suggests that many students feel alienated by what they believe are STEM subject identities and struggle to picture themselves in STEM careers. It may be helpful in this respect to introduce them to a broader range of STEM career identities and to correct and broaden the range of stereotypes related to STEM education and careers. In terms of an education programme, this may entail new thinking about both course profiles and composition. For example, a Masters programme in environmental engineering could introduce a course in applied technology for renewable energy sources in the first year, instead of after two years of groundwork in mathematics and chemistry. Science, technology, engineering and mathematics industries may be able to add to students’ knowledge about possible STEM identities by making the opportunities they offer more visible to students. Nanotechnology, for example, has possible applications both in making boats go faster through water and in making nerves grow to cure paralysis. These are two research areas that may attract quite different student identities. Typical late-modern girls may find it easier to picture themselves in STEM subjects and careers if they know more about the many opportunities STEM careers offer for helping other people. Role models are often promoted as influential sources of advice and information about various career possibilities. They may come in the shape of likeable tutors from university mathematics departments, enthusiastic and knowledgeable media commentators on STEM issues or fictional forensic crime experts in TV shows.

One approach shown to be effective is personal meetings with a mentor or ‘significant other’. This is particularly important for young women, who rely more than young men on personal relationships and advice. Female role models that challenge STEM stereotypes are particularly valuable, since young women tend to find traditional stereotypes less attractive than do men. Moreover, a possible strategy might be to make parents, teachers and others with whom young people relate aware of the important role they can play in helping young people make their educational choices and to alert these ‘significant others’ to how STEM subjects may actually accommodate a wide variety of job preferences and people with a range of values and aims. Teachers are in a unique position to communicate such information to students.

3.1.3 Utility value

In many educational systems, post-compulsory STEM subjects offer extra credits and qualifications that facilitate admission to university studies. The literature suggests that such extrinsic rewards do attract many students to these subjects in school and that removing these rewards contributes to lower participation rates. It is therefore possible to exploit this utility value to encourage more students into post-compulsory STEM subjects. The literature suggests that students are particularly eager to keep their options open. They may therefore be tempted to choose STEM subjects if they knew more about the range of opportunities that are open to students completing upper secondary school with the appropriate courses. Having many options open is attractive to late-modern young people because it increases their chances of finding a self-realising career that fits their identity. It also reduces the risk of failure in their identity development project.
As well as removing barriers to the initial choice of STEM subjects and courses, consideration must be given to ensuring that students are not faced with additional hurdles to STEM careers. The challenge is then to provide students in STEM subjects and courses with sound and authentic reasons to pursue STEM career paths. These motivational aspects can be integrated into course materials and experiences, for example, introductions to a variety of attractive STEM career options.

3.1.4 Relative cost
In the literature we find that STEM subjects, studies and careers are associated with significant personal costs. This suggests that initiatives to increase participation could aim at reducing young people’s perception of these costs relative to the benefits that STEM subjects and studies offer. It may not be feasible or even desirable to change the STEM subjects’ reputation as difficult and demanding compared to most other subjects. However, it seems possible to make those characteristics less costly and reduce fear of failure in STEM subjects. One approach is to communicate that STEM subjects are challenging, but that this very fact contributes to making them attractive to pursue — in much the same way as sports-interested youth may be motivated to exercise in order to beat their own (or someone else’s) previous records. Another approach may be to initiate study groups, tutoring and homework support programmes in order to reduce students’ fear of failure. Such programmes can also increase expectation of success, interest-enjoyment and attainment value by using tutors who can build confidence, present subject matter in interesting and enjoyable ways and function as role models who help students picture themselves in STEM careers. Role models may also help in reducing another cost identified in the literature: the geek-label and other negative characteristics associated with students choosing STEM. For late-modern young people, it costs to choose a subject that carries an identity in conflict with one’s own. Special attention may be given to reduce the costs for young women by removing the stereotype threat that they are less capable than men in STEM subjects and adjusting the subjects’ reputations as objective, values-free and masculine in nature. It also appears that STEM education programmes and workplaces are likely to recruit more young women if they encourage female-friendly work environments and ensure careers can be combined with family life. On a final note, it is important to reduce the described costs relative to the interest-enjoyment, attainment and utility value. The total influence of expectation of success and subjective values determines whether or not a student chooses a subject. Reducing the costs is a clear aim for efforts to increase participation, but the remaining costs may be seen as worthwhile in view of the increased subjective value.

3.1.5 Expectation of success
It is an obvious challenge that many students have low expectations of success in STEM subjects and that it is often lower than their expectation of success in school more generally. Young women have been found to develop efficacy more through social interaction and less through task achievement than young men (Zeldin et al., 2008). Study groups and organised homework help may therefore increase young women’s expectations of success in particular. It could also be that the traditional focus on ‘right or wrong’ answers makes expectation of success in STEM subjects typically ‘either/or’ and that this benefits young men’s efficacy development more
than young women’s. Teaching and assessment methods that provide opportunities for experiences of mastery during activities and not only when the correct answer is obtained, may encourage efficacy development for both genders. It is alarming that stereotype threats suggesting women are less talented in mathematics than men actually lead to poorer performance (Quinn & Spencer, 2001). This stereotype is unfounded and should be removed once and for all. Finally, the positive relationship between expectation of success and subjective values should be acknowledged. Allowing students to work with subject matter that interests them and is important to them may increase their expectation of success.

3.1.6 Even more pressure on teachers?

Our recommendations and those of others (for example Hazari et al., 2010; Institution of Engineering and Technology, 2008) suggest that teachers are key actors in the efforts to increase participation in STEM education and careers. However, teachers struggle with demanding schedules, large student groups and high piles of tests and reports to grade. There is not much time left over for initiating new approaches for increased participation. Any new teaching strategies or materials should therefore be easily accessible, require little additional preparation and be straightforward to incorporate into the curriculum. To make full use of the potential influence teachers have on students’ choices, their everyday work structures must allow it.

3.2 Implications for research

This article suggests that future research on increasing participation in STEM subjects and careers may benefit from using the Eccles et al. model as a framework and that the presented perspectives from sociological theories on late-modernity and identity development offer helpful additional insight in such research. Further it implies that the science and mathematics education literature reviewed here provides good starting points for generating research questions and hypotheses.

The discussion above recommended ways of increasing STEM participation by seeing research findings through the lens of a model for educational choice. However, to develop the most fruitful approaches, research must identify what works and how. To date, little in-depth research has been conducted on the effects of STEM recruitment initiatives (Jensen & Henriksen, 2010). It would, for example, be valuable to see studies on whether role models can help students picture themselves in STEM careers. Despite their expectations, Hazari et al. (2010) could not conclude whether female scientist role models informed young women’s physics identity. Studies concerning how much young people (in different age groups and educational levels) know about the wide range of possible STEM applications and careers would also contribute to the discussion. As another example, the effects of tutor programmes and study groups should be evaluated as results could address the questions of whether they encourage students to choose STEM subjects and ultimately STEM careers, whether they help develop expectations of success or deal with fear of failure or enhance student interest.

This article argues that young people in highly developed countries are affected by the late-modern zeitgeist when they make STEM-related choices. It is hoped that future studies will further explore this phenomenon. Pertinent research questions could include: How important is it for young people to realise themselves through an
educational choice? To what extent is an upper secondary subject choice an identity choice? How do young people evaluate the risks and benefits involved in choosing STEM subjects and careers?

Some specific issues related to gender differences and young women’s choices have been outlined in this article. These issues should also be addressed specifically by research. For example, can better information about applications in health care and environmental protection attract more young women to physics? How can stereotype threats be battled in classrooms and textbooks? Science and mathematics education are likely to benefit from more knowledge about the interplay of expectation of success and subjective values involved in students’ decision-making. We might therefore ask how students weigh these components up against each other. Are some subjective values more influential than others? Are there hierarchies of expectations and values that differ characteristically between groups of young people: students in different countries, from different social backgrounds or of different genders or ethnicity? It must not be forgotten that initiatives meant to increase the participation of young women may work equally well to recruit and retain more diverse groups of young men (Labudde et al., 2000). Further, the diversity of outlooks among young women and men is extensive, so gender in itself is a poor predictor of, say, interest in physics or expectation of success in mathematics.

4. Concluding remarks

Many of the initiatives and directions for further research that have been suggested in this article are by no means new. However, since the level of young people’s participation in STEM is still a pressing issue, science and mathematics educators, researchers and other stakeholders need to continue to focus on exploring solutions and to implement them and evaluate what works in practice. The conclusions and suggestions presented in this article can contribute to structuring future research and development related to improving STEM participation. We believe the framework of the Eccles et al. expectancy-value model, with additional perspectives from sociological theories of late-modernity, is not only useful for understanding young people’s participation in STEM, but for designing and evaluating initiatives.

In this article we have tried to contribute to a structured and empirically grounded understanding of the considerations that guide young people in their decisions to pursue (or not to pursue) a STEM education and career. Braced with such understanding, we have proposed measures that may increase the diversity of personalities that may feel attracted to STEM so that the future workforce within these fields will not only be greater in numbers and more even in gender distribution, but will generally include a greater multitude and variety of outlooks, experiences and aims. Such diversity may spark new ways of thinking and new applications of STEM knowledge for the benefit of the individual and for society. Moreover, inviting new groups of young people into STEM educations and careers may give them opportunities for fulfilling and self-realising experiences and help them pursue their goals for meaningful lives and careers.

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Science Choices in Norwegian Upper Secondary School: What Matters?

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ABSTRACT: There is international concern about young people’s participation in science. This study investigated the relevant importance of various issues in 1628 Norwegian upper secondary students’ choices of postcompulsory subject combinations: natural science and mathematics (henceforth Science) or languages, social science and economics (henceforth HumSoc). Questionnaire items based on the Eccles et al. model of achievement-related choices were grouped into six constructs by factor analysis: expectation of success, interest-enjoyment value, self-realization value, fit to personal beliefs value, utility value for university admission, and relative cost. Interest-enjoyment and fit to personal beliefs were somewhat less important to Science students than to HumSoc students, especially to girls taking Science. Utility value for university admission was much more important to Science than to HumSoc students, and more important to Science girls than to Science boys. Costs in terms of time and effort were much more important to HumSoc than to Science students. The findings indicate that students choose Science both for identity reasons, such as interests, self-realization and fit to personal beliefs, and for strategic utility reasons. Some of the students, especially the girls, appear to have placed more weight on utility than on their interests. Implications for participation in postcompulsory science are discussed.


INTRODUCTION
Throughout the developed world, government, industry, and educators have called for increased participation in science, technology, engineering, and mathematics (STEM) fields. Public health and well-being rely increasingly on science and technology, and industry

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is ever more dependent on technology development. Moreover, science and technology play increasing roles in society and everyday life, both of which makes scientific literacy and participation in STEM fields more and more important to the general public. Bøe, Henriksen, Lyons, and Schreiner (2011) previously stated that participation in STEM is important for five reasons: to fill demands for STEM professionals, to ensure a greater diversity of STEM professionals to increase the innovative potential, to improve empowerment of groups that are currently underrepresented in STEM fields, to give everyone the chance to experience the wonders of science and technology, and to ensure that everyone has a real free choice of education by reducing mental and cultural barriers arising from stereotypical views of scientists. Women are still underrepresented in STEM in most developed societies, and the imbalance is most severe in physical science and engineering (European Union, 2009; National Science Foundation, 2006).

Many researchers have highlighted the prevalence of disenchantment with school science among students in developed countries (Osborne, Simon, & Tytler, 2009; Schreiner, 2006; Schreiner & Sjøberg, 2007; Tytler, Osborne, Williams, Tytler, & Clark, 2008). Young people's increasing reluctance to participate in science in especially physical science and mathematics subjects has been most evident in highly developed and modernized regions such as Europe (European Round Table of Industrialists, 2009; Organization for Economic Cooperation and Development [OECD], 2008), the United States (Stine & Matthews, 2009), Australia (Lyons & Quinn, 2010), New Zealand (Hipkins & Bolstad, 2005a), Canada (Government of Canada, 2007), Japan (OECD, 2007b; Ogura, 2005), and Korea (Anderson, Chiu, & Yore, 2010). Educators agree that enrolment patterns are difficult to investigate and compare over time and between countries, due to the absence of a precise and agreed classification system and complete statistics (OECD, 2008). Nevertheless, it appears clear that a decreasing proportion of the total student pool choose to study STEM in higher education. Young women opt out in particular of physics, engineering, and technology especially.

Norwegian students generally spend 3 years in upper secondary school. Students who choose general studies and specialization to general studies (Figure 1) all take the same compulsory subjects in the first secondary year (Year 11), but choose one of three program areas

![Figure 1. Norwegian upper secondary school system with possible paths from Year 11 General Studies (vocational upper secondary training is not included in the figure) (vilbli.no, 2010). Students in paths illustrated by gray dotted lines were outside the target group.](image-url)
for the next 2 years. According to the Norwegian Directorate for Education and Training ([NDET], 2009a), 40% of students in Year 12 in 2008 chose Science, 53% chose HumSoc, and 5% chose arts, crafts, and design (these students are outside the target group and not included in this study). Girls accounted for 46% of the Science students and as much as 60% of the HumSoc students (Statistics Norway, personal communication, June 29, 2009).

Many countries have reported that a decreasing proportion of upper secondary students choose science and mathematics, for example, Australia (Lyons & Quinn, 2010), the United Kingdom (Institute of Physics, 2010), New Zealand (Hipkins & Bolstad, 2005b), and India (Garg & Gupta, 2003). In Norway, however, there has been a slight upturn in the number of Norwegian students finishing upper secondary school with a comprehensive grounding in science and mathematics (Hægeland, Kirkebøen, & Skogstrøm, 2007). In Year 12 in 2007–2008, Level 1 courses in physics, chemistry, and mathematics for natural sciences were the most popular among Science students. However, one-third of the physics students and one-quarter of the chemistry students did not continue with the subjects to Level 2 in Year 13. In contrast, 97% of biology Level 1 students took biology Level 2 in Year 13 in 2008–2009 (NDET, 2009a). The gender distribution in the science subjects follows traditional patterns: Level 2 biology, chemistry, and physics had roughly equal numbers of students in 2008–2009 (NDET, 2009a), but girls made up 69%, 57%, and 30% of students in biology, chemistry, and physics, respectively (NDET, 2009b). Many researchers have suggested that females are reluctant to participate in the physical sciences and engineering due to a perceived lack of relevance and fit to personal values (Eccles, 2007; Kozoll & Osborne, 2004; Osborne, Simon, & Collins, 2003; Ramberg, 2006; Schreiner & Sjøberg, 2007; Taconis & Kessels, 2009). The “Lily” study draws on this important perspective where an expectancy-value model of educational choices is employed to study young people’s choices in secondary education.

The Lily study is a quantitative survey about the educational choices of around 14,000 Norwegian students in secondary and tertiary education. It aims to contribute to increased participation in STEM by producing generalizable knowledge about why students do or do not choose science-related subjects and studies. The results presented in this article use data from a sample of Year 12 upper secondary students undertaking specialization in general studies. The students responded to a questionnaire early in Year 12 and had recently chosen their program area for the last 2 years of upper secondary school, Years 12 and 13 (Figure 1). This choice is critical as the Science program area is a requirement for higher education STEM studies (Norwegian Ministry of Education and Research, 2010).

The questionnaire is based on Eccles et al.’s expectancy-value model of achievement-related choices (Eccles et al., 1983). The underlying premise of expectancy-value theory is that choice, persistence, and performance can be explained by beliefs about how well the individual will perform in a particular activity and the extent to which that individual values the activity (Wigfield & Eccles, 2000). The motivation for educational choice thus consists of two main factors: the students’ expectation of success and the value the students place on this particular option. The model predicts that students are most likely to choose courses they think they can master and that have high value for them (Eccles, Barber, & Jozefowicz, 1999). It is important to underline that educational decisions are made in a complex social context: Each individual is presented with a variety of options, all of which have various consequences for their lives (Eccles et al., 1999). Two constructs directly influence achievement-related choices: expectation of success and subjective task value. Eccles et al. (1999) previously showed that both predict career choices. Their model predicts that the expectation of success and subjective task value are the result of several psychological and social/cultural parameters, for example, self-concept of abilities and personal goals, as well as the cultural milieu and the socializers’ behavior (Eccles &
Wigfield, 2002). The model has been developed and tested over many years and in many studies (see Eccles et al., 1983, 1999; Meece, Wigfield, & Eccles, 1990; Nagy et al., 2008).

Expectation of success is defined as “individuals’ beliefs about how well they will do on upcoming tasks” (Eccles & Wigfield, 2002, p. 119), and is similar to Bandura’s self-efficacy beliefs (see, e.g., Bandura, 1997, 2007; Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). For example, what constitutes success in two courses—advanced mathematics and economics—in upper secondary school depends on the students’ self-images in relation to these courses. A just above-average mark in mathematics may be a success if the students view themselves as average mathematics students but a failure if they view themselves as very good mathematics students. Expectation of success also includes the students’ perception of the level of difficulty of the courses. If they regard advanced mathematics as more difficult than economics, they may characterize a just above-average mark in advanced mathematics a major success, whereas equal success in economics would require a top mark.

In the model, subjective (task) value is split into four components: interest-enjoyment value, attainment value, utility value, and relative cost. Interest-enjoyment value concerns how interested students are in the subject in question and the enjoyment experienced when engaging in it. It is similar to intrinsic motivation (Ryan & Deci, 2000), flow (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003), and interest (Hidi & Renninger, 2006; Krapp, 2002, 2005). Students who are, for example, political activists are possibly quite interested in community economics. They may, therefore, enjoy economics and statistics more than calculus, and an economics course will have higher interest-enjoyment value for them than advanced mathematics.

Attainment value refers to how well a subject or career choice fits with a person’s identity. People want to confirm central aspects of their identity and will attribute higher value to options that enable them to establish this identity (Eccles, 2009). The importance of succeeding to fulfill personal needs is also a part of attainment value (Eccles, 1994). An educational choice may have attainment value for students because it makes them feel happy and proud of themselves, or because it is stimulating to work creatively and overcome challenges. For instance, for someone who wants to confirm and express an identity as very intelligent, an advanced mathematics course may have higher attainment value than economics, because mathematics is generally considered to be more difficult than most other subjects. Similarly, it may be important not to choose subjects that appear to be in conflict with a desired identity. If physics is perceived to be for brainy and unpopular geeks, physics will have low attainment value for someone who rejects such an identity.

Utility value concerns how helpful a certain course is in reaching external goals, such as career objectives. A choice that has high utility value, therefore, leads to extrinsic motivation (Ryan & Deci, 2000). Universities also often award more credits for upper secondary advanced mathematics than economics, a factor that may give the former higher utility value for some students. Extrinsic motivation causes people to engage in activities to obtain a separate outcome. Physics may have high utility value for students who hope to gain entry to medical school, even if they have no personal interest in the subject.

Relative cost refers to negative aspects related to one activity or educational choice compared with other options. It could, for example, be the time and effort that is required to do well in advanced mathematics compared to economics. It could be fear of failing
advanced mathematics, or fear of disappointing parents. Lost opportunities from choosing one course or study program over another are also relative costs.

According to the model, identity influences both expectation of success and subjective values and is influential when students make educational choices (Eccles, 2009). Eccles and colleagues distinguished between personal and social or collective identities. Students’ personal identity includes their self-image and their values and goals. It also includes what kind of person they think they may become in the future (possible future selves). Students’ social identities are how they see themselves in terms of social categories and how they express membership of these categories through symbols and activities. Students try to fit educational choices into their identities. When developing their identity, students use stereotypes related to jobs, subjects, and activities, all of which are defined by culture and are often gender specific. Young people have their own perceptions of each stereotype; these perceptions are also influenced by those of parents, peers, and other socializers.

Much science education research has identified differences between girls and boys, and gender has been thoroughly addressed by Eccles and colleagues in the expectancy-value model of achievement-related choices (Eccles, 1994, 2007; Eccles et al., 1999; Nagy et al., 2008). The model suggests that culture, through gender and gender-specific stereotypes, socializes boys and girls differently. Eccles and colleagues (1999, 2009) stated that these socialization processes may lead to the genders developing different hierarchies of core personal values and cause boys and girls to place different values on activities due to stereotypical notions of gender-specific activities. To construct a desired identity, the same educational choice may have very different value for boys and girls. A girl who wishes to study medicine and a boy who wants to become an engineer both place high utility value on physics in upper secondary school, because it is required for university admission later on. However, although a physics student stereotype may be easily incorporated into a technically oriented engineer identity, it may be less compatible with a care-oriented medical practitioner identity.

Science educators have found that the Eccles et al. model is a suitable framework for studying young people’s choices of science (Bøe et al., 2011). Among the model’s strengths is its comprehensive and inclusive nature. It is comprehensive in the sense that it incorporates social, psychological, and cultural aspects that influence educational choices, and it is inclusive in the sense that many of its construct overlap with concepts from other motivational theories (see Eccles & Wigfield, 2002), such as Bandura’s (1997) theory of self-efficacy, Ryan and Deci’s (2000) theory of intrinsic and extrinsic motivation, and Hidi and Renninger’s (2006) and Krapp’s (2002, 2005) theory of interest. Another strength is that it acknowledges identity as an important factor in educational choices (Eccles, 2009; Eccles & Wigfield, 2002). A few issues have been identified that require consideration when the model is used in science education research (Bøe et al., 2011). First, expectation of success and subjective values are affected by constantly changing society and cultural milieu. This makes measures of expectation of success and subjective values sensitive to cultural changes. Second, social background variables such as ethnicity and class could be stated more clearly in the model. Third, researchers should note that the expectancy-value structure of the model does not imply that choices are made through a fully informed calculation of all the available options. For example, interest-enjoyment value has major affective components and may be based on a “gut feeling.”

Wigfield and Eccles (1992) stressed how social surroundings influence young people’s expectancies, their self-schema, their perception of stereotypes, and the subjective values they attach to educational options. I, therefore, include perspectives from sociology about late modernity and identity development, to understand better the social and cultural setting in which young Norwegians make their choices.

Young people in rich, developed nations such as the Nordic countries live in a society that the sociologist Giddens (1991) calls late modern. The late modern period needs to be distinguished from the general modern age, which has characterized developed societies in past centuries. The modern age was triggered by the industrial revolution, and values supporting economic growth were central (Inglehart, 1997). Characteristics of late modern societies include less emphasis on material values and more emphasis on personal ones, such as self-realization and quality of life. Late modernity can be seen as a continuation of modernity into a late and accelerated stage, rather than an epochal shift into what some theorists call postmodernity. A postmodern society is described as highly pluralistic and diverse, with no universal principles, common ideas, or grand narratives that can direct social development (Giddens, 1991). In contrast, late modernity is recognized by the radicalization, amplification, and intensification of modernity (Beck, Giddens, & Lash, 1994; Fornäs, 1995; Miles, 2000). A central mechanism in late modernity is detraditionalization where authorities and tradition have lost much of their influence (Beck et al., 1994). Detraditionalization results in a concept referred to as individualization where each individual is more culturally liberated and can to a larger extent than in more traditional societies make specific choices in relation to factors such as lifestyle, place to live, education and jobs, political views, life partner, and religious faith. Individualization brings with it the freedom to take control of one's own life and the task of making the best of it. In this task of self-realization, the quality and meaning of life are central (Inglehart, 1997).

Identity construction plays a major role in individualization. In a society less bound by tradition, identity is no longer inherited or given but must be constructed by the individual (Côté, 1996; Giddens, 1991). Adolescence, therefore, becomes a crucial period, with individuals seeking their own identity and trying to fit many choices into a consistent person. Young people see their interests, their favorite school subjects, their job plans, their friends, and their views (on science and technology and everything else) as part of their identity, of who they are (Beck, 1999; Goffman, 1959). Large parts of their days are spent with other young people in a range of activities such as school, dance class, football practice, cinemas, cafés, and chat rooms. All of this gives rise to youth culture, a stage where identity construction takes place. Today's social life offers multiple contexts of action, making lifestyle choices increasingly important in the establishment of self-identity (Giddens, 1991). Sociologists like Giddens, Beck, and Inglehart described late modernity in the 1990s, and the period's characteristic traits have also been recognized in more recent work (Bauman, 2008; Furlong & Cartmel, 2007). However, it is important to note that late modernity provides an idea of free choice. Class, gender, and other constraints of social life continue to limit young people's life chances, but have been obscured (Atkinson, 2008; Furlong & Cartmel, 2007). As a result, young people hold themselves responsible if they cannot resolve problems on their own, even if these problems are rooted in social constraints (Furlong & Cartmel, 2007).

Recently, science and mathematics educators have increased their focus on the societal changes taking place in most developed countries (Tytler, 2007) and on the role that identity plays in young people's orientations to science and mathematics (Aikenhead, 2006; Osborne et al., 2009; Sfard & Prusak, 2005). Several contributions to science education research have related young people's identity work to their orientations to science (Archer et al., 2010; Brickhouse, 2001; Brickhouse, Lowery, & Schultz, 2000; Brickhouse & Potter, 2001; Hazari, Sonnert, Sadler, & Shanahan, 2010; Kozoll & Osborne, 2004; Schreiner, 2006; Taconis & Kessels, 2009).

This article investigates the relevant importance of different issues for Norwegian upper secondary students who chose Science and HumSoc and discusses implications for participation in postcompulsory science.
### TABLE 1
Distribution According to Program Area and Gender

<table>
<thead>
<tr>
<th>Group</th>
<th>Respondents (%)</th>
<th>Population (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>21.1</td>
<td>19.8</td>
</tr>
<tr>
<td>Boys</td>
<td>24.1</td>
<td>23.1</td>
</tr>
<tr>
<td>HumSoc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>33.8</td>
<td>34.2</td>
</tr>
<tr>
<td>Boys</td>
<td>20.9</td>
<td>22.9</td>
</tr>
</tbody>
</table>

*Statistics Norway, personal communication, June 29, 2009.*

### METHODS

The survey data were collected during the autumn 2008 term from a sample of Norwegian Year 12 students undertaking general studies specialization. Prior to the data collection, the students had chosen their program area for Years 12 and 13 and decided whether or not to continue with science. For practicality reasons, the students were sampled in clusters. Seventy-three Norwegian upper secondary schools were randomly selected from a list of all schools that fit the target group: schools that offered the standard science program area as an option in specialization in general studies. Forty-two (58%) of the selected schools participated. The data collection was administered by teachers at each school, and 1628 students in the two program areas Science and HumSoc (short for Humanities (including languages and economics) and Social studies) participated. The filled out questionnaires were returned by post. Because of the low response rate, the representativity of the sample is addressed by comparing the distribution on gender and program area in the sample to that of the population (Table 1). The geographical distribution of respondents was also investigated and found to be representative.

The questionnaires contained 120 closed Likert-type questions, in addition to two open-ended questions. A focus group interview was conducted prior to the administration of the questionnaires. The five participants filled out the questionnaire individually, followed by a group discussion about various aspects of the questionnaire such as interpretation, length and format, difficulty of answering, and general impression. Their responses were used to revise the questionnaire. The questionnaire used a 4-point scale with no neutral midcategory to prevent respondents using a midcategory response as an “I don’t know” or “does not apply” response (Kulas, Stachowski, & Haynes, 2008), and force them to express an opinion. On the front page of the questionnaire, respondents were instructed to leave the space blank if they found that none of the alternatives fitted, or if they did not understand the question. The midcategories 2 and 3 were not named, thereby encouraging respondents to interpret the distance between the boxes as equal (Cummins & Gullone, 2000). The constructs (Table 2) were formed by factor analysis of the question “How important were the following factors for you in your choice of programme area?”: The question listed 20 items to which the respondents gave their answers on a scale from “not important” (coded with the value 1) to “very important” (coded with the value 4). Missing values on these items ranged from 1.4% to 2.4%, and cases were excluded listwise in the factor analysis.

The factor analysis was exploratory. Although the questionnaire items are based on the Eccles et al. model, the retrospective nature of the study suggests that this theoretical basis is not sufficient to redefine constructs (Fabrigar, Wegener, MacCallum, & Strahan, 1999).
TABLE 2
Descriptive Statistics for Constructs

<table>
<thead>
<tr>
<th>Factor</th>
<th>Construct</th>
<th>Questionnaire Items</th>
<th>α</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interest-enjoyment value</td>
<td>That I would have fun with the subjects</td>
<td>.69</td>
<td>3.29</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>That I would learn about something I am interested in</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-realization value</td>
<td>That I would be able to develop myself</td>
<td>.74</td>
<td>2.97</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>That I would be able to use my talents and abilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>That I would be challenged</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>That I would be able to work creatively</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Fit to personal beliefs value</td>
<td>That I would learn about something I find important and meaningful</td>
<td>.72</td>
<td>2.89</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>That I would learn about something that fits my beliefs and values</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>That I would learn about something that is important for society</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Utility value for university admission</td>
<td>To collect as many credits as possible</td>
<td>.73</td>
<td>2.79</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entrance requirements for further studies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>To keep many options for further studies open</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expectation of success</td>
<td>My previous marks</td>
<td>.64</td>
<td>2.79</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td>My chances to get good marks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Relative cost</td>
<td>That the program area would not be too difficult</td>
<td>.85</td>
<td>2.02</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>That the program area would not demand too much work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>That I would have time for things beside school work</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The question was “How important were the following factors for you in your choice of programme area?,” on a scale from Not important (1) to Very important (4).

Principal axis factoring was used to extract factors and does not assume normally distributed data but assumes that the data are continuous (SPSS, 2009). If ordinal data do not have strong floor or ceiling effects, Likert scales with four (B. Muthén, personal communication, September 16, 2009) and five (Finney & DiStefano, 2006) categories can be approximated as continuous. The factor solution was rotated by Direct Oblimin rotation. This oblique rotation allows the factors to be correlated (Fabrigar et al., 1999), as the factors are predicted by the Eccles et al. model to be. All analyses were performed using SPSS (SPSS, 2009).

To create constructs and ensure that the items in the construct measured something they have in common, the factors were tested for internal consistency using Cronbach’s alpha where .7 is an accepted cutoff point for attitudinal measures (Gable & Wolf, 1993). Test of unidimensionality was performed to determine whether items had more than one aspect in common. The interitem correlations in a construct were between .3 and .8 (Hellevik, 2002), with low dispersion. For each factor, a new factor analysis was conducted on only the items.
in the factor to determine whether they returned only one factor even if the eigenvalue criterion was lowered to .75. With this eigenvalue criterion, any factor that explained more than \( .75/n \) (where \( n \) is the number of items in the factor) of the total variance was extracted. Factors that failed to meet one of these criteria were assumed to measure more than one common trait and consequently split into more than one construct. For a factor to be used as a construct, its items should also have quite clear loading patterns rather than only weak loadings spread on two or more factors. One item (“That I would not be a minority as a boy/girl”) was excluded prior to the factor analysis due to strong floor effects (skewness \( >2 \) and kurtosis \( >7 \); Curran, West, & Finch, 1996). Two more items (“That the programme area had a good image” and ”What my friends chose”) were placed together in one factor by the factor solution. However, they showed unclear loading patterns and, therefore, were not included in the resulting constructs (Table 2).

Interaction effects between gender and program area were identified through linear regression analysis (Cohen, Cohen, West, & Aiken, 2003). Hierarchical multiple regression tests were performed where comparison of \( R^2 \)-squared correlations determined whether including an interaction term in the model yielded a significant change in its explanatory power (Jaccard, Turrisi, & Wan, 1990). The reported effect sizes of differences of means were measured by Cohen’s \( d^2 \) (Cohen, 1992). A 99% confidence interval was consistently used to evaluate the statistical significance of differences of means. This quite conservative criterion was employed because the cluster sampling of schools, as opposed to randomly sampling students, implies that the true standard error is larger than what is observed in the data.

The questionnaire also included 37 items regarding priorities in a future job under the heading “How important are the following factors for your future occupation or job?” Although the entire question was not well suited for factor analysis, it included five items that correspond to items in the question about choice of program area and that form two constructs that satisfy the criteria for internal consistency and unidimensionality. Scores on these constructs are reported in this article to inform the discussion about choice of program area. Missing values on the items in these constructs ranged from 1.5% to 2.6%.

Six constructs—based on the Eccles et al. model—were used to measure the importance of various issues for students’ choices of upper secondary program area. Differences between girls and boys and Science and HumSoc students were examined, as well differences between subgroups of gender and program area.

RESULTS

Factor analysis identified four factors that yielded six constructs with satisfactory internal consistency and unidimensionality. Two factors were multidimensional in the second factor analysis test and were both split into two constructs. The typical mean interitem correlation of all six constructs was .5, and the gaps between the weakest and the strongest correlations were all less than .2. The constructs with Cronbach’s alpha (\( \alpha \)), mean score (\( M \)), and standard deviation (\( SD \)) for the sample are given in Table 2.

“That I would have fun with the subjects” and “That I would learn about something I am interested in”\(^3\) made up the construct interest-enjoyment value referred to in the Eccles et al.

\[ d = M_1 - M_2 / \sqrt{SD_1^2 + SD_2^2} / 2, \] where \( M_1 \) and \( M_2 \) are the means and \( SD_1 \) and \( SD_2 \) the standard deviations, in the two groups.

\(^3\)“That I would learn about something I am interested in” loaded slightly stronger on Factor 2 than on Factor 1. However, it was placed in Factor 1 because of its conceptual meaning and because the loadings were of similar size.

TABLE 3
Effect Sizes for Differences of Gender and Program Area

<table>
<thead>
<tr>
<th>Construct</th>
<th>Girls–Boys</th>
<th>Science–HumSoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest-enjoyment value</td>
<td>0.15**</td>
<td>−0.29**</td>
</tr>
<tr>
<td>Self-realization value</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Fit to personal beliefs value</td>
<td>0.23**</td>
<td>−0.27**</td>
</tr>
<tr>
<td>Expectation of success</td>
<td>0.20**</td>
<td>−0.03</td>
</tr>
<tr>
<td>Utility value for university admission</td>
<td>0.04</td>
<td>0.90**</td>
</tr>
<tr>
<td>Relative cost</td>
<td>−0.12</td>
<td>−0.76**</td>
</tr>
</tbody>
</table>

Note: Cohen’s d. 
**p < .01.

model. “That I would be able to develop myself,” “That I would be able to use my talents and abilities,” “That I would be challenged,” and “That I would be able to work creatively” formed a construct I interpreted as self-realization value, whereas “That I would learn about something I find important and meaningful,” “That I would learn about something that fits my beliefs and values,” and “That I would learn about something that is important for society” made up the construct fit to personal beliefs value.

“My previous marks” and “My chances to get good marks” formed the construct expectation of success. “To collect as many credits as possible,” “Entrance requirements for further studies,” and “To keep many options for further studies open” formed the construct utility value for university admission, whereas the items “That the programme area would not be too difficult,” “That the programme area would not demand too much work,” and “That I would have time for things beside school work” made up the construct relative cost, which corresponds to the relative cost in the Eccles et al. model.

The effect sizes of differences in mean scores are expressed by Cohen’s d. Table 3 shows the differences between girls and boys and the differences between Science and HumSoc students, and Table 4 shows differences between subgroups of each gender in each program area. Interaction effects between gender and program area were identified for one of the six constructs: interest-enjoyment value. Nevertheless, as there are significant differences in mean scores between subgroups of gender and program area also on other constructs, all differences are reported here.

TABLE 4
Effect Sizes for Differences Between Combinations of Gender and Program Area

<table>
<thead>
<tr>
<th>Construct</th>
<th>ScG–ScH</th>
<th>HSG–HSB</th>
<th>ScG–HSG</th>
<th>ScB–HSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest-enjoyment value</td>
<td>−0.11</td>
<td>0.30**</td>
<td>−0.48**</td>
<td>−0.05</td>
</tr>
<tr>
<td>Self-realization value</td>
<td>−0.08</td>
<td>0.11</td>
<td>−0.06</td>
<td>0.12</td>
</tr>
<tr>
<td>Fit to personal beliefs value</td>
<td>0.13</td>
<td>0.26**</td>
<td>−0.32**</td>
<td>−0.15</td>
</tr>
<tr>
<td>Expectation of success</td>
<td>0.25**</td>
<td>0.15</td>
<td>0.05</td>
<td>−0.05</td>
</tr>
<tr>
<td>Utility value for university admission</td>
<td>0.31**</td>
<td>0.10</td>
<td>1.02**</td>
<td>0.82**</td>
</tr>
<tr>
<td>Relative cost</td>
<td>−0.17</td>
<td>−0.31**</td>
<td>−0.76**</td>
<td>−0.86**</td>
</tr>
</tbody>
</table>

Note: Sc = Science, HS = HumSoc, G = girls, B = boys.

*Cohen’s d. 
**p < .01.
TABLE 5 Descriptive Statistics for Constructs

<table>
<thead>
<tr>
<th>Construct</th>
<th>Questionnaire Items</th>
<th>α</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest and self-realization in future job</td>
<td>Working with something I am interested in...</td>
<td>.73</td>
<td>3.59</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>Using my talents and abilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developing myself</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fit to personal beliefs in future job</td>
<td>Working with something that fits my beliefs and values</td>
<td>.72</td>
<td>3.36</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Working with something I find meaningful</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The question was “How important are the following factors for your future occupation or job?,” on a scale from Not important (1) to Very important (4).

The mean scores presented in Table 2 show that the respondents found it easy to agree that interest-enjoyment (3.29), self-realization (2.97), and fit to personal beliefs (2.89) were important in their choice of program area. However, interest-enjoyment and fit to personal beliefs were somewhat less important to Science than HumSoc students (d = −0.29 and d = −0.27, respectively, Table 3). That gender interacted with program area for interest-enjoyment value is illustrated by a difference of d = −0.48 between girls in Science and HumSoc, whereas, in contrast there was no significant difference between boys in the two program areas. Science girls’ scores stood out in a way that cannot be explained by the fact that they are Science students or by the fact that they are girls. In terms of the importance of utility value for university admission, Science students scored much higher than HumSoc students. To some extent, this is trivial because items in that construct describe formal admission qualifications that are only available to Science students (Norwegian Universities and Colleges Admission Service, 2010). Interestingly, the utility value for university admission was also more important to Science girls than to Science boys (d = 0.31). There was also a small difference between Science girls and boys in the importance of expectation of success (d = 0.25), though a corresponding difference between girls and boys in general (d = 0.20, Table 3) suggests that this was mainly a gender effect. Avoiding costs in time and effort was much more important to HumSoc students than to Science students (d = −0.76).

Scores on two more constructs (Table 5) were included that consist of items from another question concerning priorities in future jobs.

Girls scored higher than boys on interest and self-realization in future job and fit to personal beliefs in future job, with significant gender effects of d = 0.40 and d = 0.45, respectively. There was no significant difference between Science and HumSoc students or between Science and HumSoc girls specifically, which contrasts with the observed differences in the importance of interest-enjoyment value and fit to personal beliefs value in choice of program area.

DISCUSSION AND IMPLICATIONS FOR POSTCOMPULSORY PARTICIPATION

High scores on interest-enjoyment value, self-realization value, and fit to personal beliefs value show that most students want their program area to be interesting, meaningful, and self-realizing. This finding is not surprising in the light of sociological theories on late modernity, which stress that young people search for activities that they find interesting and meaningful (Inglehart, 1997), and that they can identify with (Beck, 1999; Giddens, *Science Education*, Vol. 96, No. 1, pp. 1–20 (2012))
These three constructs were closely related (all interconstruct correlations were greater than 0.5), and I understand them to be related to the importance of identity and identity development. Both subjective value and expectation of success have been shown to be influenced by identity (Eccles, 1994, 2009), which is especially important to young people who are in the midst of forging their identity and who view interests, activities, worldviews, subject choices, and job plans as part of who they are (Beck, 1999; Frønes, 1995; Goffman, 1959). Science educators have argued that to appreciate science, students need to make science part of their identity (Aikenhead, 2006; Kozoll & Osborne, 2004).

Even if Science students scored somewhat lower than HumSoc students on interest-enjoyment value and fit to personal beliefs value, the findings suggest that these were important issues to students who chose science. The finding also indicates that many Science students expect their program area to be interesting and personally meaningful. The challenge is, therefore, to meet these expectations. Cleaves (2005) previously reported that some students experience disappointment with school science and do not continue. Moreover, science interest has been shown to decrease throughout schooling, for girls in particular (Osborne et al., 2003). Popular characteristics of school science as having transmissive pedagogy, decontextualized content, and being unnecessarily difficult (Lyons, 2006) suggest that some of the most enthusiastic students may not find the meaningful and important topics they expect in the Science program area.

The results show clearly that utility value for university admission was very important for many Science students. These findings are in line with several studies that have found that instrumental reasons are important in the selection of upper secondary science and mathematics (Angell, Guttersrud, Henriksen, & Isnes, 2004; Hutchinson, Stagg, & Bentley, 2009; Lie, Angell, & Rohatgi, 2010; Lyons, 2006; Osborne & Collins, 2001). Among such instrumental reasons is the desire to keep as many options as possible open. In their study of Year 13 students in New Zealand, Hipkins and Bolstad (2006) found that many students stayed in science to keep their options open. This also appears to be an important motivation for Norwegian students and can be seen as a sign that young people want to ensure that every path to a happy, fulfilled, and self-realized life is available. In Beck’s (1999) and Beck and Beck-Gernsheim’s (2002) individualized risk society, young people have the opportunity to create their own identity but also assume the responsibility for making the most of it. They face the risk of failing their identity project and need to keep as many doors open as possible, until the right choice becomes clear.

The fact that many students appear to have chosen science for strategic reasons points to both challenges and opportunities for upper secondary science. First, the subjects must fulfill the needs of students with very different motives for choosing science. Students who chose physics because of a passionate interest in the subject will require something quite different from the teacher than those who chose it for the credits, in spite of their interests. Second, lessons provide an everyday arena where schools and textbooks can show the most strategic students that STEM education and careers can be interesting and self-realizing. Hipkins and Bolstad (2006) asked how the science curriculum can become more relevant to students’ concerns and help them learn more about the wide range of science-related research and careers. Cleaves (2005) argued that lack of knowledge about possible science careers keeps students from choosing science. In light of the findings presented here, these questions are also appropriate for Norwegian science educators.

Science girls scored higher than Science boys on the importance of utility value for university admission. Although the difference was not large, it suggests that Science girls chose program areas more strategically than Science boys. Other studies have also found that girls choose science more strategically than boys: Miller, Blessing, and Schwartz (2006) reported that young women often planned science majors mainly because they needed it.
to enter health professions such as medicine. In a U.K. study, Bennett and Hogarth (2009) found that among students who viewed chemistry positively, more young women than men did so for career reasons. In addition, in many countries, more women than men attend higher performing, academically oriented tracks and schools (OECD, 2007a). The fact that Science girls stood out from HumSoc girls with smaller scores on interest-enjoyment and fit to personal beliefs suggests that some Science girls placed more weight on the utility argument than on their interests and personal beliefs. When asked about their priorities in relation to a future job, however, there was no significant difference between Science and HumSoc girls on the importance of interests and fit to personal beliefs. Moreover, in both program areas, girls scored higher on these constructs than boys. This finding indicates that Science girls are just as focused as HumSoc girls on finding interesting and meaningful jobs, but that some of them let the utility argument weigh more than interests and personal beliefs in their choice of program area.

Girls tend to put more emphasis than boys on idealistic values, such as helping other people (Schreiner, Henriksen, Sjaastad, Jensen, & Løken, 2010; Schreiner & Sjøberg, 2007). Alarmingly, Eccles (2009) reported that placing a high value on helping other people is predictive of not choosing careers related to physical science. A decontextualized, value-free notion of science will be especially alienating to girls (Osborne et al., 2009), and many girls may opt out of subjects if they do not offer extra credits or required qualifications, especially if the subjects do not appear personally meaningful to them. This may partly explain why the proportion of girls in Norwegian physics classrooms dropped from 40% in Year 12 to 30% in Year 13 (NDET, 2009b). Very few Norwegian universities have Year 13 physics as an entrance requirement.

The results clearly show that HumSoc students placed more importance than Science students on avoiding costs associated with difficult and demanding subjects. Given that these attributes typify physical science and mathematics (Angell et al., 2004; Carlone, 2003; Osborne & Collins, 2001; Tytler et al., 2008), this result is not surprising. It indicates, however, that some HumSoc students chose not to study science due to these costs. To persuade some of these students to choose science downplaying the difficulty or time needed to master these subjects is not necessarily the correct approach. The subjects’ reputation as being more difficult than most subjects is possibly rightfully earned. Therefore, rather than misleading students to choose a program area they are not prepared for, recruitment initiatives should emphasize how interesting and meaningful topics can make the effort worthwhile. Subjects that appear both difficult, time consuming and uninteresting, and irrelevant are poorly matched to late modern ideals such as self-fulfillment (Beck & Beck-Gernsheim, 2002) and meaningfulness (Frønes & Brusdal, 2001; Giddens, 1991).

Science subjects’ reputation as particularly difficult is also likely to affect students’ expectation of success in these subjects. This study found that girls placed somewhat more weight than boys on expectation of success in their choice of program area. As girls have been found to have lower self-efficacy in science and mathematics than boys (Barnes, McInerney, & Marsh, 2005; Cavallo, Rozman, & Potter, 2004; Lloyd, Walsh, & Yailagh, 2005; Lyons, 2006; Preckel, Goetz, Pekrun, & Kleine, 2008; Simpkins, Davis-Kean, & Eccles, 2006), this finding indicates that increasing girls’ expectation of success may be a useful approach to make more girls to choose science.

Several studies have found that young people make up their minds about whether or not to study science at an early age (Tytler et al., 2008). Results from a recent Australian study, however, have challenged this claim with more than 80% of 15-year-olds stating that their experiences in the lower secondary years were most influential for their choice (Lyons & Quinn, 2010). The results presented in this article indicate that many students have not made up their minds at age 16–17 years. However, identity and self-realization are central

in every choice modern young people make (Illeris, Katznelson, Simonsen, & Ulriksen, 2002), and students can only be persuaded to pursue STEM further if they are introduced to opportunities where their interests and identity can be met. To encourage more students to continue with STEM, the subjects in the Science program area could present to them a wide range of further studies and careers. It may be fruitful to present careers in both pure and applied sciences. Sjaastad (2010) found that more Norwegian students in pure science than applied science higher education reported that their teacher had inspired and motivated them in their educational choice. It appears that school science is more able to advertise careers related directly to pure science subjects per se, than the wide range of applied science careers available.

This article has shown how the Eccles et al. expectancy-value model of achievement-related choices can be used in a retrospective approach to study young people’s educational choices. The model predicts a causal link between students’ expectation of success and subjective values and an achievement-related choice. To investigate such a causal relationship, a longitudinal design is required. For example, students’ expectations and values related to the Science program area could be measured at a time prior to their decision making and whether these students chose science would be assessed at a later date. Such an approach was not feasible in the Lily study as the data were collected retrospectively after the choice in question had been made. By using respondents’ self-reports, the items measured the importance that the respondents placed on various factors when they made their choice of program area. The six constructs interest-enjoyment value, self-realization value, fit to personal beliefs value, utility value for university admission, expectation of success, and relative cost form a valid instrument that can be used and developed further in future research. It is important to note that a factor solution is a product of the responses and may be unfit for another data set. The representativity of the sample was, therefore, needed for the factor analysis is to be generalized or used to generate theory. The large sample size (1628) was another strength of the study, as the factor analysis procedure used assumes continuous data and bias caused by nonnormality or the categorical nature of data decreases with sample size (Finney & DiStefano, 2006).

The constructs are not identical to the concepts in the Eccles et al. model. “That I would be able to develop myself,” “That I would be able to use my talents and abilities,” “That I would be challenged,” and “That I would be able to work creatively” formed the construct self-realization value. In a sense, these four items tap into attainment value in the Eccles et al. model because they can be understood as part of identity development. However, they concern development toward a future self more than confirmation of a current identity. The two latter items address the importance of reaching cognitive goals such as creativity and overcoming challenges. Eccles and Wigfield (2002) placed this in attainment value, and I suggest it can also be seen as part of self-realization and identity development. As the fit to personal beliefs value can be seen as measuring the importance of the subjects’ fit to central parts of one’s identity (Giddens, 1991; Goffman, 1959), both self-realization value and fit to personal beliefs value may be understood in the light of attainment value in the Eccles et al. model. The expectation of success construct had an alpha of .64. Although this is weak for a construct, the construct consisted of only two items, and the alpha increases with the number of items. Moreover, as the interitem correlation was .47 and the meaning of the items is easily interpretable, I used it as a construct. However, the construct only concerned outcome expectations in terms of marks, not a broader sense of self-concept or feeling of mastery. Eccles and Wigfield (2002) reported that young people cannot distinguish between their

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4 Particle physics and biochemistry research are examples of what is here considered pure science, whereas engineering in construction and the oil industry are examples of applied science.
general abilities and outcome expectations on specific tasks. It is therefore likely that the respondents’ expectations of marks reflect their self-concepts in the subjects they chose. However, it may have been preferable to include more items concerning expectation of success in this study. One possibility would have been to include students’ own experiences of success or efficacy. For example, “That I felt confident about my abilities in the subjects” and “That I felt I would master the subject matter.” The inclusion of such experiences may have improved the construct, and future research would benefit from adding them. In the light of the terminology in the Eccles et al. model, it is also important to note that the items in the utility for university admission construct only ask about the program area’s utility for admission to universities. The question could have asked about the importance of a broader utility or outcome expectations (Hazari et al., 2010), such as the possibility for high salaries or a secure job. The focus on the utility for university admission is based on the suspicion that the choice of upper secondary science and mathematics is often motivated by the credits and formal qualifications students are awarded in many educational systems.

The fact that self-realization value and fit to personal beliefs value emerged instead of attainment value is partly due to the questions that were asked. The questionnaire included items about the importance of choosing subjects that are self-developing and personally important and meaningful because these appear to be central determinants in young people’s science-related choices. Science education research has indicated that many students view school science as irrelevant to them personally (Sjøberg, 2003; Tytler et al., 2008) and that more attention should be given to the role that identity development plays in young people’s orientations to school science (Aikenhead, 2006; Osborne et al., 2009; Schreiner, 2006). Including such items in the Lily study enabled the investigation of an interesting trait in modern youth culture, namely that young people constantly contemplate how well educational choices can serve their self-realization (Illeris et al., 2002).

I selected the Eccles et al. model partly because it is comprehensive and inclusive. The comprehensive and inclusive nature of the model also illustrates the undoubtedly complex process involved in making educational choices. A science-related choice can take many potential pathways (Cleaves, 2005), include both unconscious and conscious decision making (OECD, 2008), and not least be made over time (Vaughan, 2005). Consequently, there are many possible approaches to studying these choices and no single study can provide a comprehensive picture. Instead of the 25 items used in this article, the questionnaire could have listed 200 or 15 entirely different items. Other theoretical perspectives could also have been applied when developing the questionnaire that may have led to other interpretations and implications. For example, questions developed solely under the guidance of Bandura’s self-efficacy framework would be quite different: Fewer items would ask about the importance of subjective value and development, and more items would ask about self-efficacy-beliefs.

To broaden our understanding of the science choices of Norwegian upper secondary students, it would be valuable to investigate the choice process more qualitatively through, for example, in-depth interviews. A qualitative approach could, for example, yield insight into how concepts such as interest-enjoyment value are evaluated by students deciding whether to continue with science. It could also identify some of the complex pathways educational choices may follow. Longitudinal studies, both quantitative and qualitative, could help investigate how choices about participation in science develop over time.

**CONCLUSIONS**

This study assessed Norwegian Year 12 students’ choices of Science or HumSoc as their upper secondary program area. Six constructs based on the Eccles et al. model
of achievement-related choices were created that measured the importance of interest-enjoyment value, self-realization value, fit to personal beliefs value, utility value for university admission, expectation of success, and relative cost for the students’ choices. Scores on these constructs indicated that most students, in both Science and HumSoc, want their program area to be interesting, meaningful, and self-realizing. This finding is not surprising in late modern societies where young people search for interesting and meaningful activities that fit their identities. It is important that the Science subjects enthuse students and meet their expectations in terms of exciting and meaningful subject matter.

Science students also had high scores on the importance of utility value for university admission, suggesting that many students chose science for strategic reasons. In particular, utility value was somewhat more important to Science girls than to Science boys. At the same time, Science girls scored lower than girls in HumSoc on the importance of interest-enjoyment and fit to personal beliefs. It appears that some girls chose Science not only strategically, but also in spite of their interests. It may be particularly challenging to keep such students engaged and motivated in the classroom. However, the subjects in the Science program area have the opportunity to give them more than instrumental reasons to continue by introducing them to interesting and self-realizing subject matter and career opportunities.

Very few Science students stated that it was important to avoid costs in time and effort, but this was much more important to HumSoc students. This reflects the general view that science and mathematics subjects are more difficult and time consuming than most other subjects and implies that some students selected HumSoc to avoid difficult and demanding subject matter.

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ARTICLE III
Love it or leave it
Norwegian students’ motivations and expectations for post-compulsory physics

Maria Vetleseter Bøe and Ellen K. Henriksen

Abstract
In response to the challenge of insufficient participation and female under-representation in physics education and careers, this article uses questionnaire data from Norwegian physics students in upper secondary (N=585) and first-year tertiary (N=278) education to characterize the “physics choosers”. An expectancy-value perspective is adopted to describe the motivations and expectations behind the respondents’ physics choice. Secondary students were largely motivated by interests, self-realization and/or the utility value of physics for university admission, and many of them planned to go into medicine (females in particular) or engineering (males in particular). Tertiary physics students appeared to be motivated by a passion for the subject, high interest and expectation of enjoyment, and many of them planned to go into research. Females expressed lower self-concepts of ability than males, and were more idealistically oriented concerning future job. However, gender differences were less prominent among tertiary than secondary students. The results are discussed against descriptions of a physics discipline culture, and implications for improved participation in physics are proposed.

Keywords: physics choice, participation, interest, gender, expectancy-value
Introduction

Background and aims

Physics is one of the disciplines within science, technology, engineering and mathematics (STEM) fields where young people’s participation has been regarded as unsatisfactory. Skilled physicists are needed to understand and help solve global challenges such as climate change, energy shortage, environmental problems, and medical diagnostics. Increasing reluctance to participate in the physical sciences has been especially evident in highly developed parts of the world such as Europe (European Round Table of Industrialists, 2009; OECD, 2008), the US (Stine & Matthews, 2009), Australia (Lyons & Quinn, 2010), New Zealand (Hipkins & Bolstad, 2005), Canada (Government of Canada, 2007), Japan (OECD, 2007; Ogura, 2005) and Korea (Anderson, Chiu, & Yore, 2010). Females in school and university tend to be underrepresented in physics, engineering, mathematics and technology subjects, and overrepresented in the life and health sciences (Dobson, 2007; EU, 2006, 2009; National Science Board [NSB], 2010; National Science Foundation, 2006). Bøe, Henriksen, Lyons and Schreiner (2011) gave five reasons why participation in STEM is an important issue. Among these reasons were that society needs more people in STEM professions to fill demands, but also that STEM needs a greater diversity of professionals (more females in particular) in order to develop in new ways, and that increased participation from under-represented groups enhances the empowerment of such groups. These arguments apply to participation challenges within physics, and there has been a number of calls for better understanding of and responses to these challenges (American Institute of Physics, 2011; Norwegian Ministry of Education and Research, 2010; OECD, 2008). The participation challenges in physics have been linked to a pronounced discipline culture that is at odds with a desired personal identity (Taconis & Kessels, 2009) and may appear alienating to many young people, females in particular (Murphy & Whitelegg, 2006).

In this article we use data from the quantitative study Lily about the educational choices of Norwegian students in secondary and tertiary education. Findings from the Lily material have previously been reported in Sjaastad (2011), Henriksen, Jensen, and Sjaastad (2012), and Bøe (2012).

In this article we aim to answer:
- What characterizes the motivations and expectations of Norwegian students who have chosen physics in secondary and tertiary education?

- What characterizes the educational and occupational aspirations of Norwegian students who have chosen physics in secondary or tertiary education?

Based on the answers to these two questions, we also ask

- How do these characterizations relate to descriptions of a physics discipline culture?

For each question, the gender dimension is included in the analysis. Based on the analyses, we will discuss implications for improved participation in physics. What we mean by improved participation is linked to the reasons for why STEM participation is a problem, as stated by Bøe et al. (2011). Improved participation in physics involves an increase in the number of students who enroll in and complete a university physics study; a wider range of priorities and perspectives represented among physics practitioners than is currently the case; and an increase of participants from currently under-represented groups, females in particular. The latter is important to enhance empowerment for under-represented groups. Choosing a physics-related career involves acquiring knowledge and taking part in decision-making that concerns many people’s lives.

**Physics – a pronounced discipline culture**

Physics in upper secondary school as well as in higher education is characterized by a pronounced discipline culture. For the purposes of this article, the term physics discipline culture refers to the practices and values that dominate and are endorsed in secondary physics classrooms and university physics studies. A university study in physics as a discipline will by necessity be dominated by basic content-knowledge, rational discourse and substantial mathematical rigor. However, the research literature suggests that upper secondary physics practices, too, emphasize these aspects at the expense of physics in historical and social contexts: Duit, Niedderer and Schecker (2007, p. 624) observed that “physics instruction in school includes a certain canon of content that is quite similar all over the world”. Carlone (2003) used the term ‘prototypical physics’ for a discipline envisioned as difficult, hierarchical, objective, rigorous and elitist, and she saw this as undermining the goals of a more inclusive physics. Angell, Guttersrud, Henriksen, and Isnes (2004) described Norwegian school physics as a ‘closed system’ with few, but satisfied participants. Both students and teachers were happy with an orientation towards physics
content and basic laws rather than on physics history, contexts and processes. The instruction appeared to be dominated by “chalk and talk” where the teacher presented and explained from the blackboard followed by individual problem-solving. Similar emphasis on “traditional” physics instruction at the expense of historical, philosophical and science and society approaches has been observed in physics classrooms also in Denmark (EVA, 2001), Germany (Häussler & Hoffmann, 2000), and the UK (Osborne & Collins, 2001). The TIMSS Advanced study also found Norwegian physics classroom activities to be dominated by teachers’ explanations and individual problem-solving (Lie, Angell, & Rohatgi, 2010).

**Physics as particularly difficult and demanding**

Physics has a long tradition of being perceived as difficult (Carlone, 2003; Osborne & Collins, 2001), in particular by female students (Angell et al., 2004; Duit et al., 2007). Angell et al. (2004) found that physics students in Norway, to a larger extent than those studying English or social science students, regarded their subject as difficult, having a high workload and fast progression through the curriculum. Similar findings have been reported by Drury and Allen (2002) and Woolnough (1994). Educators have argued that physics may be inherently difficult, due to its many forms of representation (Dolin, 2002), high level of abstraction (Duit, 2007), and a way of thinking that requires a border crossing from the students’ everyday world (Krogh & Thomsen, 2005). The perception of difficulty has been found to contribute to students opting out of physical science (Lyons & Quinn, 2010; Murphy & Whitelegg, 2006).

**Interest as the main motivation for choosing physics**

The literature reveals the typical physics student as largely motivated by interest and enjoyment with physics (Adams et al., 2006; Angell et al., 2004; Lyons & Quinn, 2010; Reid & Skryabina, 2002; Rødseth & Bungum, 2010; Ulriksen, 2010). Hazari, Sonnert, Sadler, and Shanahan (2010) found that wanting an intrinsically fulfilling career was typical for a physics identity, which in turn predicted choice of physics. The authors also pointed to the importance of encouragement by significant adults for students’ persistence in studies in physical science (Hazari et al., 2010). Several researchers have found that female physics students are particularly likely to be inspired by a parent (Hasse, Sinding, & Trentemøller, 2008; Hazari, Sadler, & Tai, 2008). Studies also point to students’ self-concepts in physics as important for post-compulsory participation (Krogh & Thomsen, 2005; Murphy & Whitelegg, 2006). Additionally, the utility value of physics for higher education has been
identified as an important reason why students choose secondary physics (Angell et al., 2004; Lie et al., 2010; Lyons, 2006).

Krogh and Thomsen (2005) looked at three different “purposes of knowledge acquisition” (PKA) among Danish upper secondary physics students: The ‘savior-PKA’, capturing “the extent to which students acquire knowledge with the purpose of doing good in the world or to people”, ‘the conqueror-PKA’, accounting for students who study “with the purpose of gaining personal independence and access to the world in future careers”, and the ‘absorption-PKA’, describing how some students mainly study to “get wiser themselves” (Krogh & Thomsen, 2005, p. 289). They found that the savior-PKA was dominant in their sample, especially among the female students. The authors remarked that acculturation into the physics classroom would be easier for students with an absorption-PKA, as this was most in line with the knowledge ideal and work forms in the physics education culture. Other science educators have also related young people’s relationship to and participation in physics to identity and/or to border crossing between cultures (Carlone, 2004; Hazari et al., 2010; Taconis & Kessels, 2009).

**Female under-representation in physics**

Females tend to be under-represented in physics education (Dobson, 2007; EU, 2009; Murphy & Whitelegg, 2006; NSB, 2010), and discussions about why this is the case have gone on for decades. One central issue in such debates is whether or not these differences, so persistent over time, spring from genetic differences, for example, in mathematical aptitude, between males and females. This article focuses on socio-cultural factors and constraints which constitute a powerful explanatory factor behind females’ under-representation (Ceci, Williams, & Barnett, 2009).

Warrington and Younger (2000) pointed out that mathematics and science subjects are socially constructed as masculine, and claimed that physics classroom processes tend to alienate female students, and that females to a larger degree describe physics as very difficult and demanding. Females generally have lower self-concept of ability in physics than males do (Häussler & Hoffmann, 2002; Lyons, 2006; Murphy & Whitelegg, 2006). Lindstrøm and Sharma (2011) found that Australian female first-year university physics students consistently reported lower self-efficacy than their male peers. Moreover, in their study of German physics students, Häussler and Hoffmann (2000) found that males’ physics-related self-concept was higher than their general school-related self-concepts,
whereas the opposite was found for female students. Murphy and Whitelegg (2006) claimed that many female students may not feel a sense of ‘belonging’ in physics, and suggested that choosing physics might be interpreted as “a gender transgressive act which challenges a key signifier of femininity” (Murphy & Whitelegg, 2006, p. 287). Danielsson (2009) argued that doing physics is also “doing gender”, and that taking on a physics identity for a female student requires distancing oneself from what is “traditionally” female. These are quite recent descriptions from highly developed countries, and do not necessarily apply to different cultural contexts or times.

**Physics participation in Norway**

Norwegian students meet physics as part of an integrated school science throughout compulsory school (Years 1-10) and in the first year of upper secondary school. Beyond that, students in the pre-academic Specialization in general studies can take post-compulsory physics and other science subjects separately in Years 12 and 13. More specifically, they choose between normally three program areas Languages, social science and economics, Science, and Arts, crafts and design. Within these programs, students choose (usually) three courses to follow in addition to their compulsory courses (history, Norwegian, etc.). The science program area offers physics, biology, chemistry, earth science, mathematics, and a few other subjects. In 2007–2008, Level 1 physics was among the most popular courses among Year 12 students in the Science program area. Nevertheless, one third of the students who took Level 1 physics in 2007-2008, chose not to continue to Level 2. In contrast, 97% of biology Level 1 students continued to biology Level 2 (Norwegian Directorate for Education and Training [NDET], 2009a). A likely explanation for this opt-out of Level 2 physics is that a significant proportion of students choose Level 1 physics primarily to qualify for specific higher education programs, or to keep many options open (Angell et al., 2004; Bøe, 2012; Lie et al., 2010), as Level 1 physics is required for far more higher education programs than Level 2 physics. In 2008, the gender distribution in the science subjects followed traditional patterns: females were over-represented in biology and under-represented in physics (NDET, 2009b). The percentage of Norwegian upper secondary students who choose physics has been rather stable over the last 15 years (Angell, Bungum, et al., 2011). The physics student proportion of the entire higher education student population has decreased radically since the 1970s. Females made up roughly one third of Norwegian tertiary physics students in 2008 (Norwegian Social Science Data Services, 2009).
Theoretical perspectives

Various science education researchers have suggested that many students – females in particular – are reluctant to participate in the physical sciences and engineering due to a perceived lack of relevance and fit to personal values (Eccles, 2007; Kozoll & Osborne, 2004; Osborne, Simon, & Collins, 2003; Ramberg, 2006; Schreiner & Sjøberg, 2007; Taconis & Kessels, 2009). The Lily study draws on this perspective and employs the Eccles et al. expectancy-value model of achievement-related choices (Eccles et al., 1983) to study young people’s educational and occupational choices. The underlying premise of expectancy-value theory is that choice, persistence, and performance can be explained by the individual’s beliefs about how well they will perform in a particular activity and the extent to which they value the activity (Wigfield & Eccles, 2000, p. 68). The model predicts that students are most likely to choose courses they think they can master, and that have high value for them (Eccles, Barber, & Jozefowicz, 1999). Expectation of success concerns how well students believe they will perform in, for example, a school subject they may choose to take. It includes both the students’ self-concept of ability and their impression of the difficulty of the subject. In the model, subjective (task) value is split into four components:

- Interest-enjoyment value concerns how interested students are in the subject in question and the enjoyment they expect to experience when engaging in it.
- Attainment value refers to how well a subject or career choice fits with a person’s identity. People want to confirm central aspects of their identity and will attribute higher value to options that enable them to establish this identity (Eccles, 2009).
- Utility value concerns how helpful a certain course is in reaching external goals, such as admission to higher education or plans for future career.
- Relative cost refers to negative aspects related to one activity or educational choice compared with other options.

The model predicts that both expectation of success and subjective value are affected by several psychological and social/cultural variables, for example, self-concept of abilities and personal goals, as well as the cultural milieu and the socializers’ behavior (Eccles & Wigfield, 2002). The model has been developed and tested over many years and in many

* Eccles and colleagues use the term subjective task value. As this article concerns the choice of school subjects and educational programs, rather than specific tasks, we use subjective value.
studies (see Eccles et al., 1983; Eccles et al., 1999; Meece, Wigfield, & Eccles, 1990; Nagy et al., 2008). According to the model, identity influences both expectation of success and subjective values, attainment value in particular (Eccles, 2009). Students try to fit educational choices into their identities, and are influenced by stereotypes related to jobs, subjects and activities, all of which are defined by culture and are often gender specific. Young people have their own perceptions of each stereotype; these perceptions are also influenced by those of parents, peers and other socializers. Bøe et al. (2011) presented central parts of the Eccles et al. model and demonstrated how a large amount of research literature on young people’s relationship to STEM could be interpreted in the light of the model and inform the discussion about STEM-related choices. Their analysis of the model showed that it was a fruitful tool for designing and analyzing empirical studies of young people’s STEM-related choices, and it has been used accordingly in the Lily study.

We further draw on theories from sociology about late modernity and identity development (Giddens, 1991), in order to better understand the social and cultural setting in which young Norwegians make their choices. Characteristics of late-modern societies include less emphasis on material values and more emphasis on personal ones, such as self-realization and quality of life. Each individual is more culturally liberated and can to a larger extent than in more traditional societies make individual choices in relation to, for example, education and job. This liberation is a result of a less tradition-bound society, where identity is no longer inherited or given but must be constructed by the individual (Côté, 1996; Giddens, 1991). Young people see their interests, their favorite school subjects, their job plans, their activities and personal beliefs as part of their identity, of who they are (Beck, 1999; Goffman, 1959). Sociologists like Giddens, Beck and Inglehart described late modernity in the 1990s, and the period’s characteristic traits have also been recognized in more recent work (Bauman, 2008; Furlong & Cartmel, 2007). However, it is important to note that late modernity provides an idea of free choice. Class, gender and other constraints of social life continue to limit young people’s life chances, but have been obscured (Atkinson, 2008; Furlong & Cartmel, 2007).
Methods

Respondents and instrument

The Lily study collected self-report data from 14,000 students in more than 100 upper secondary schools and around 30 universities and university colleges in 2008. Data from four student groups provided the results presented in this article. The SECONDARY PHYSICS STUDENTS were students enrolled in the course Level 1 Physics in Year 12 of upper secondary school. THE TERTIARY PHYSICS STUDENTS were students enrolled in a first-year higher education physics study†. THE SECONDARY HUMSOC STUDENTS were students enrolled in the program area Languages, social science, and economics in Year 12 of upper secondary school. THE NSEC STUDENTS were students enrolled in the first year at the economics and business administration program at the Norwegian School of Economics (NSEC). The secondary HumSoc and tertiary NSEC samples were included for comparison with physics students at the secondary and tertiary levels, respectively. All HumSoc students rather than students enrolled in one specific HumSoc course were used for comparisons with physics students, because it was difficult to find one course with a similar standing in the HumSoc program area as the one held by Level 1 physics in the science program area. The NSEC students were used for comparisons with physics students because they were the most clear-cut non-science student group that was expressing positive attitudes to school science and mathematics (Schreiner, Henriksen, Sjaastad, Jensen, & Løken, 2010). They were thus considered as students who may have considered higher education STEM studies, but chose not to pursue them.

The secondary school data were collected during the autumn 2008 term. For practicality reasons, the students were sampled in clusters. Seventy-three eligible Norwegian upper secondary schools were randomly selected from a list of all schools that fit the target group: schools that offered the standard Science program area as an option in Specialization in General Studies. Forty-two (58%) of the selected schools participated. The data collection was administered by teachers at each school, and 1,628 students in the two program areas Science and HumSoc participated. Prior to the data collection the participants had chosen a program area for Year 12, and they had chosen which courses to follow among those offered by the program area. The filled-in questionnaires were returned by post. Bøe (2012) has shown that the sample is comparable to the population regarding gender

† The definition of physics study here is largely based on Statistics Norway’s classification of Norwegian educational programs according to the International Standard Classification of Education (ISCED).
distribution and program area. 585 of the respondents reported that they followed the Level 1 physics course. The representativeness of the gender distribution is demonstrated in TABLE 1.

The tertiary education data were collected in 2008, during the students’ first week of the first term as students of university physics or at NSEC. The survey was administered locally at the universities during a lecture or obligatory information meeting, and all students were given the questionnaire. The samples were, therefore, not randomly selected but comprise the entire population of tertiary physics students in Norway. The number of respondents, the total number of students in the population, and the gender distributions are shown in TABLE 1.

TABLE 1: Gender distribution among respondents and student populations

<table>
<thead>
<tr>
<th>Group</th>
<th>Population (sec)</th>
<th>Respondents (sec)</th>
<th>Population (tert)</th>
<th>Respondents (tert)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics</td>
<td>7809 (40 %)</td>
<td>585 (42 %)</td>
<td>349 (31 %)</td>
<td>278 (32 %)</td>
</tr>
<tr>
<td>HUMSOC/ NSEC (tertiary)</td>
<td>12 886 (60 %)</td>
<td>892 (62 %)</td>
<td>449 (44 %)</td>
<td>274 (45 %)</td>
</tr>
</tbody>
</table>

a(Norwegian Directorate for Education and Training, personal communication, September 19, 2011)
b(Norwegian Directorate for Education and Training, personal communication, October 12, 2009)

The questionnaires‡ to all groups of respondents were to a great extent similar, and consisted of approximately 120 closed Likert-type questions in addition to a few open questions. A focus group interview was conducted among each target group as part of the development and validation of the instruments. Focus group participants filled in the questionnaires individually, followed by a group discussion about various aspects of the questionnaire such as interpretation, length and format, difficulty of answering and general impression. Their responses were used to revise the questionnaires. The questionnaires used a 4-point scale with no neutral mid-category to prevent respondents using a mid-category response as an ”I don’t know”- or ”does not apply”-response (Kulas, Stachowski, & Haynes, 2008). The mid-categories 2 and 3 were not labeled, thereby encouraging respondents to

interpret the distance between the boxes as equal (Cummins & Gullone, 2000). The 4-point scale responses were coded with values 1 (“Small extent”, “Not important”, “Disagree”), 2, 3, and 4 (“Great extent”, “Very important”, “Agree”).

Data analyses

Several questions in the questionnaires, each with a set of items, asked about the respondents’ inspiration and motivation for choosing as they did, their expectations for the subjects/study they had chosen, and their plans and priorities regarding a future job. This article investigates students’ choices of physics in secondary and tertiary education. The secondary students’ choice was to attend the science program area and to include Level 1 physics among their specified courses. As a consequence, the students’ responses concern not only physics, but a combination of (usually) three post-compulsory courses of which Level 1 physics was one. The questionnaire sometimes referred to the ‘program area’ and sometimes to the ‘subjects’ the students had chosen. In addition to physics, 91% of the students also followed Level 1 mathematics for natural sciences and 70% followed Level 1 chemistry. The tertiary physics students’ choice was to enroll in a higher education program classified as physics. Those study programs also included courses in other subjects, especially mathematics.

Mean scores on construct measures (henceforth termed measures) and on single items will be presented. Measures were created by means of exploratory factor analyses. Although some of the questions and items were based on the Eccles et al. model, this theoretical basis was not sufficient to pre-define measures (Fabrigar, Wegener, MacCallum, & Strahan, 1999). Principal axis factoring was used to extract factors as it does not assume normally distributed data but assumes that the data are continuous (SPSS, 2009). If ordinal data do not have strong floor or ceiling effects, Likert-scales with four (B. Muthén, personal communication, September 16, 2009) and five (Finney & DiStefano, 2006) categories can be approximated as continuous. The factor solutions were rotated by an oblique rotation allowing the factors to be correlated (Fabrigar et al., 1999), as most factors in this study are predicted by the Eccles et al. model to be. All analyses were performed using SPSS (SPSS, 2009). The factors were tested for internal consistency using Cronbach’s alpha, and the recommended cut-off point for attitudinal measures of .7 (Gable & Wolf, 1993) was employed as a guide. Unidimensionality of each measure was investigated by looking at the dispersion of inter-item correlations and at the stability of each factor when doing a factor analysis including only the items in a measure. One item (“Working with something I am
interested in”), from the question concerning priorities in future job, was excluded prior to the factor analysis due to strong ceiling effects (skewness >2 and kurtosis >7, Curran, West, & Finch, 1996). The measures were formed by separate factor analyses on responses from secondary and tertiary physics students. To allow for comparisons, all measures were in addition also checked for internal consistency and unidimensionality for the HumSoe and NSEC samples. The reported effect sizes of differences of means were measured by Cohen’s $d$ (Cohen, 1992). A 99% confidence interval was consistently used to evaluate the statistical significance of differences of means (independent sample t-tests) and correlations in the secondary sample.** This seemingly strict criterion was employed because the cluster sampling of schools, as opposed to randomly sampling students, implies that the true standard error is larger than what is observed in the data.

Results from two open questions are included in this article, one concerning sources of inspiration and one asking what kind of a job respondents wanted. Responses from secondary and tertiary physics students to the first question were analyzed qualitatively using the AtlasTi software to code and retrieve quotations. An open coding process was adopted (Strauss & Corbin, 1990) where codes were mainly created inductively, based on the respondents’ actual expressions. However, the coding process was guided by the research questions and the theoretical frameworks adopted in the present work, notably the Eccles et al. model. Several codes were assigned to the same passage where appropriate. Responses were reviewed in several cycles. On the other open question “What kind of a job do you want?” the respondents could either tick a box labeled “Don’t know”, or write an answer on a dotted line. The written responses to this question were coded according to the International Standard Classification of Occupations 2008 (ISCO-08) (International Labour Organization, 2008). Additional codes were added to include references to working with research, as this was not specified directly in ISCO-08.

\[
d = \frac{M_1 - M_2}{\sqrt{\frac{(N_1 - 1)SD_1^2 + (N_2 - 1)SD_2^2}{N_1 + N_2}}},
\]

where $N_1$ and $N_2$ are the numbers of respondents, $M_1$ and $M_2$ are the means, and $SD_1$ and $SD_2$ the standard deviations, in the two groups.

** Statistical significance testing was not relevant for the tertiary sample, as it included all of the population rather than a random sample.
Results

Sources of inspiration

The respondents answered several questions concerning inspiration and motivation for their choice by sources such as parents and teachers, popular science, television programs, books, magazines, newspaper articles and poster ads, museums and science centers, and the internet and computer games. Generally, scores on these items were not high for either group of respondents. Mean scores on most items were below 2.5, indicating that a minority of students perceived their choice to be much inspired by these factors. TABLE 2 reports a selection of items where physics students reported the highest values. Physics students’ responses to an open question provide additional information on sources of inspiration for the students’ choices, and will be reported alongside the quantitative results. The question asked respondents to “name one or more experiences or activities from your background that have influenced your current choice of education (leisure activities, TV programs, Internet sites, games, books, magazines, visits to library, museum or science center, particular events, teachers or other persons who made an impression, or other …)”.

TABLE 2: Inspiration for choice – mean scores ($M$) and effect sizes ($d$)\(^a\)

<table>
<thead>
<tr>
<th>Source of inspiration</th>
<th>Secondary Physics</th>
<th>Tertiary Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females - Males</td>
<td>Females - Males</td>
</tr>
<tr>
<td></td>
<td>(Sec Ph)</td>
<td>(Tert Ph)</td>
</tr>
<tr>
<td>Teachers</td>
<td>2.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Parents</td>
<td>2.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Popular science books and magazines</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Popular science on television</td>
<td>2.5</td>
<td>2.8</td>
</tr>
</tbody>
</table>

\(^a\)Positive values indicate that the first-mentioned group scored higher.

n.s. non-significant ($p<0.01$)

n.a. not applicable (the item/measure was not measured for at least one of the groups)
Note. The questions were “To what extent have you been inspired or motivated by the following in your choice of program area [sec]/study program [tert]?”, on a scale from Small extent (1) to Great extent (4).

Parents, teachers and other persons

Inspiration from parents received the highest mean score for the secondary physics students. They scored higher on this item than their HumSoc peers, and there was no gender difference. On a question concerning the educational background of the students’ parents, more than half of the secondary physics students responded that at least one of their parents had their educational background in STEM. These students were, not surprisingly, more likely than other physics students to have high scores on inspiration from parents. But, the difference was not large – many secondary students without STEM parents also expressed that they were inspired by their parents. For tertiary physics students, however, the difference was much larger, physics students with STEM parents were much more likely than others to respond that they had been inspired by their parents. Generally, the tertiary physics students scored lower than the secondary students on inspiration from parents, but higher on inspiration from teachers. Moreover, tertiary physics students were far more likely than NSEC students to express inspiration from teachers. Inspirational teachers were also among the predominant themes in the tertiary respondents’ responses to the open question, and emerged as a far stronger source of inspiration there than in the closed questions.

“We had very good science teachers. Especially my final-year physics teacher made me choose the physics and mathematics program at the university.” (tertiary physics (TPh))

“Knowledgeable physics teacher who showed great engagement for the subject and kindled my curiosity.” (TPh)

Parents and other family members were mentioned less frequently than teachers by the tertiary respondents, but somewhat more frequently than teachers by secondary respondents. Generally, fathers were mentioned more often than mothers.

“I have in no way been pressured by my parents to choose science. But dad is a psychiatrist and has inspired and encouraged me to like science. He has bought books, taken me to science center and museum.” (Secondary Physics (SPh))

“My mother is a graduate engineer and I visited her at work one day. Then I began thinking that this might be something for me, too.” (TPh)

“A father who litters the house with “Science Illustrated” and “National Geographic”.” (TPh)
References to inspiration from siblings and other family members were also found:

“My grandfather (...) was a member of the Norwegian Physics Society.” (TPh)

“My two sisters who have both taken physics, maths and chemistry. They told me about these subjects.” (SPh)

Only five respondents in the secondary and tertiary groups combined mentioned career advisers in school as a source of inspiration.

**Popular science and recruitment initiatives**

Popular science seemed to have inspired both secondary and tertiary students to choose physics, especially popular science on television. Among the secondary physics students, however, females were less likely than males to express inspiration from popular science. A similar tendency, but of smaller effect size, was found for tertiary physics students (TABLE 2). Popular science was among the most frequently mentioned themes in both the secondary and tertiary physics students’ responses to the open question.

“Discovery and National Geographic.” (TPh)

“Podcasts (The Skeptics’ guide to the universe)- because they talk about nanotechnology.” (TPh)

“Experiments on YouTube.” (SPh)

Some of the accounts (particularly from the secondary respondents) referred to biographical material or fiction, such as films and TV drama series with science or technology content (e.g. MacGyver, CSI, and Grey’s Anatomy).

“Reading biographies about Einstein, Newton and Curie as a child has formed me.“ (TPh)

“Stargate Sg-1 [science fiction TV series]. I’m dissatisfied with the way we travel.” (TPh)

“Book: “Angels and demons”.” (SPh)

A number of respondents mentioned encounters with popular science in museums or science centers. Moreover, recruitment initiatives of various kinds appeared to have inspired some respondents to choose physics. The most commonly mentioned initiatives were school excursions or visits to or from higher education institutions, education fairs, and participation in science competitions.
“Visit to CERN with my physics class in final year.” (TPh)

“Participated in the International Physics Olympiad.” (TPh)

“Student from the university who visited our school and talked about positive experiences with science and social life at the university.” (SPh)

**Importance of motivational factors**

In a previous article based on the Lily project in upper secondary school (Bøe, 2012), six measures based on the Eccles et al. model of achievement-related choices were created that measured the importance of expectancy-value factors for the students’ choices of program area in upper secondary school. Scores for the secondary physics students on these measures (TABLE 3) imply that interest-enjoyment, utility value for university admission, and self-realization were important when they chose the Science program area including Level 1 physics. Also, the secondary physics students scored much higher than secondary HumSoc students on utility value for university admission, marginally lower on interest-enjoyment and fit to personal beliefs, and much lower on the importance of minimizing the costs in terms of difficulty and work-load. Gender differences were very small among the physics students, with the exception of utility value for university admission, on which females scored higher than males.
TABLE 3: Importance of motivational factors (secondary) – mean scores ($M$) and effect sizes ($d$)$^a$

<table>
<thead>
<tr>
<th></th>
<th>$M$</th>
<th>$d$</th>
<th>$d$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Secondary Physics</td>
<td>Females − Males (Sec Ph)</td>
<td>Sec Ph − HumSoc</td>
</tr>
<tr>
<td>Interest-enjoyment value</td>
<td>3.2</td>
<td>n.s.</td>
<td>−0.32</td>
</tr>
<tr>
<td>Self-realization value</td>
<td>3.0</td>
<td>n.s.</td>
<td>−0.29</td>
</tr>
<tr>
<td>Fit to personal beliefs value</td>
<td>2.8</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>Expectation of success</td>
<td>2.8</td>
<td>0.24</td>
<td>n.s.</td>
</tr>
<tr>
<td>Utility value for university admission</td>
<td>3.2</td>
<td>0.43</td>
<td>0.94</td>
</tr>
<tr>
<td>Relative cost</td>
<td>1.6</td>
<td>−0.27</td>
<td>−0.85</td>
</tr>
</tbody>
</table>

$^a$Positive values indicate that the first-mentioned group scored higher.

n.s. non-significant ($p<0.01$)

Note. The question was "How important were the following factors for you in your choice of program area?" on a scale from Not important (1) to Very important (4).

The tertiary students were asked a different set of items about the importance of various factors for their choice of study$^{††}$. High scores (TABLE 4) express that both the physics students and the NSEC students placed much importance on choosing a study that would challenge them and foster self-development, a study that demonstrated the relevance of what they learned for what they wanted to work with, and that opened up for different job opportunities. There were no gender differences on the first two items: Male and female students alike stressed the importance of a self-developing and clearly relevant study. However, female physics students were more likely than males to place much importance on the study opening up for different job opportunities. Tertiary physics studies and economics and business administration studies at NSEC both tend to attract students who were high-performing in secondary school. Nevertheless, NSEC students were more likely

$^{††}$ Some of these items concerned the higher education institution they chose more than the field of study, and will not be reported here.
than physics students to agree that they wanted to “make use” of their grade point average, and looked for studies with correspondingly high admission requirements. The physics students had low mean scores on these items, but females, on average, scored higher than males.

TABLE 4: Importance of motivational factors (tertiary) – mean scores ($M$) and effect sizes ($d$)\textsuperscript{a}

<table>
<thead>
<tr>
<th></th>
<th>$M$ Tertiary Physics</th>
<th>$d$ Females Males (Tert Ph)</th>
<th>$d$ Tert Ph NSEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>That you are challenged and get to develop yourself</td>
<td>3.7</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>That you see the relevance of what you learn for what you want to work with</td>
<td>3.5</td>
<td>n.s.</td>
<td>0.27</td>
</tr>
<tr>
<td>That the study opens up many different job opportunities</td>
<td>3.5</td>
<td>0.56</td>
<td>n.a.</td>
</tr>
<tr>
<td>When I applied, I was concerned that the admission requirements should correspond to my grade point average</td>
<td>2.1</td>
<td>0.50</td>
<td>−0.54</td>
</tr>
<tr>
<td>I wanted to make use of my grade point average by choosing a study program with the highest admission requirements possible for me</td>
<td>1.9</td>
<td>0.38</td>
<td>−0.51</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Positive values indicate that the first-mentioned group scored higher.

n.s. non-significant (p<0.01)
n.a. not applicable (the item/construct was not measured for at least one of the groups)

Note. The question for the first three items was “How important are the following factors for you regarding your choice of study program?” on a scale from Not important (1) to Very important (4). The question for the last two items was “To what extent do you agree with the following statements?” on a scale from Disagree (1) to Agree (4).

In response to the open question about sources of inspiration, both physics respondent groups referred predominantly to interest and enjoyment. A number of respondents ignored the direct reference to external sources in the wording of the question, and described their interest as something that “is just there” or had been there through most of their life.

“I am a curious person, and this contributes to the interest for science.” (TPh)
“Been fond of science-related stuff, so it has sort of just been there.” (SPh)

“Sorry, only [my] own interests.” (SPh)

As is apparent from the closed questions, utility value for university admission was prominent in some of the secondary responses.

“I would really like to be a doctor, therefore I chose maths, physics and chemistry.” (SPh)

“I chose science in order to have more opportunities.” (SPh)

**Expectations for the courses and study situation**

The respondents answered a question about their expectations for the program area (secondary) or the study program (tertiary) they had chosen. Some of the items were grouped into measures by factor analysis (TABLE 5). Mean scores on these measures and on a few single items are reported in TABLE 6.

*Expectation of enjoyment*

Overall, most students in all four samples expected to enjoy the subjects/study they had chosen. Scores on expectation of enjoyment were quite high for all groups, and there were no gender differences. However, tertiary physics students were the most enthusiastic, both when compared to NSEC students and, in particular, compared to secondary physics students.

*Self-concept of ability*

The measure Self-concept of ability was comprised of items regarding the students’ perceptions of their abilities in the subjects/study they had chosen. As the measure did not work well in the secondary samples, their mean scores on two of the single-items are reported instead (TABLE 6). In total, all four student groups appeared moderately positive about their abilities, although on the tertiary level, more physics students than NSEC students expressed high self-concepts. There were clear gender differences: female students were more likely than males to express low self-concepts in tertiary and secondary physics.

*Relative cost*

All students were asked to what extent they agreed that ‘this program area/study will cost me more time and effort than if I had chosen another program area/study program’. Secondary physics students scored much higher than HumSoc students on this item, and female physics students scored even higher than males. A similar gender difference was
found among tertiary physics students, whereas there were none among HumSoc or NSEC students. Secondary physics students were more likely than tertiary students to agree that they had chosen subjects with high costs in terms of required effort.
TABLE 5: Measures with questionnaire items and Cronbach’s alpha

<table>
<thead>
<tr>
<th>Measure</th>
<th>Items</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expectation of enjoyment</strong></td>
<td>I am very motivated for the subjects in this program area/study program.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I will enjoy the program area/subject area I have chosen.</td>
<td>0.75-0.83</td>
</tr>
<tr>
<td></td>
<td>The subjects/study will concern something I find exciting.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The subjects/study will address issues I find meaningful and important.</td>
<td></td>
</tr>
<tr>
<td><strong>Self-concept</strong></td>
<td>I worry that I am not good enough at the subjects in this program area/study program. (inverted scale)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I learn easily in the subjects in this study program.</td>
<td>0.69-0.72</td>
</tr>
<tr>
<td></td>
<td>I am/will be cleverer than most other students in this program area/study program.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I am better at these subjects than at subjects in other program areas/study programs.</td>
<td></td>
</tr>
<tr>
<td><strong>Idealism</strong></td>
<td>Helping other people.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taking into consideration a sustainable development, justice and protection of the environment.</td>
<td>0.75-0.81</td>
</tr>
<tr>
<td></td>
<td>Working with something that is important to society.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Working with something that fits my beliefs and values.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Working with something I find meaningful.</td>
<td></td>
</tr>
<tr>
<td><strong>Self-realization</strong></td>
<td>Using my talents and abilities.</td>
<td>0.69-0.72</td>
</tr>
<tr>
<td></td>
<td>Developing myself.</td>
<td></td>
</tr>
<tr>
<td><strong>Technology and design</strong></td>
<td>Designing and creating something new.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developing technology for renewable energy.</td>
<td>0.74-0.80</td>
</tr>
<tr>
<td></td>
<td>Developing computer or communication technology.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developing other technology.</td>
<td></td>
</tr>
<tr>
<td><strong>Research</strong></td>
<td>Doing research.</td>
<td>0.71-0.79</td>
</tr>
<tr>
<td></td>
<td>Developing new knowledge.</td>
<td></td>
</tr>
</tbody>
</table>

*a* Only used for tertiary students.

*b* Only used for secondary and tertiary physics students.

**Note.** Cronbach’s alpha was measured for each respondent group separately, and found to have values within the reported range.
TABLE 6: Expectations for the program area/study – mean scores (M) and effect sizes (d)\textsuperscript{a}

<table>
<thead>
<tr>
<th></th>
<th>Secondary Physics</th>
<th>d</th>
<th>Tertiary Physics</th>
<th>M</th>
<th>d</th>
<th>Tertiary Physics</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>d</td>
<td>d</td>
<td>M</td>
<td>d</td>
<td>Tert Ph - NSEC</td>
<td>d</td>
</tr>
<tr>
<td>Expectation of enjoyment\textsuperscript{b}</td>
<td>3.1</td>
<td>n.s.</td>
<td>n.s.</td>
<td>3.5</td>
<td>n.s.</td>
<td>0.32</td>
<td>0.81</td>
</tr>
<tr>
<td>Self-concept of ability\textsuperscript{b}</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2.8</td>
<td>-0.71</td>
<td>0.47</td>
<td>n.a.</td>
</tr>
<tr>
<td>I learn easily in the subjects\textsuperscript{c}</td>
<td>2.7</td>
<td>-0.41</td>
<td>n.s.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>I worry that I am not good enough at the subjects\textsuperscript{c}</td>
<td>2.4</td>
<td>0.51</td>
<td>n.s.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>This program area/study will cost me more time and effort than if I had chosen another program area/study\textsuperscript{c}</td>
<td>3.4</td>
<td>0.36</td>
<td>1.58</td>
<td>3.1</td>
<td>0.34</td>
<td>0.24</td>
<td>-0.34</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Positive values indicate that the first-mentioned group scored higher.

\textsuperscript{b}Measures described in TABLE 5.

\textsuperscript{c}Single items.

n.s. non-significant (p<0.01)
n.a. not applicable (the item/construct was not measured for at least one of the groups)

*Note. The question was “To what extent do you agree with the following statements about you and the program area you have chosen / study you have started?” on a scale from Disagree (1) to Agree (4).*
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>d</td>
<td>M</td>
<td>d</td>
<td>M</td>
<td>d</td>
<td>d</td>
</tr>
<tr>
<td>Idealism</td>
<td>2.9</td>
<td>0.67</td>
<td>n.s.</td>
<td>3.2</td>
<td>0.51</td>
<td>n.s.</td>
<td>0.46</td>
</tr>
<tr>
<td>Self-realization</td>
<td>3.5</td>
<td>0.38</td>
<td>n.s.</td>
<td>3.7</td>
<td>n.s.</td>
<td>n.s.</td>
<td>0.39</td>
</tr>
<tr>
<td>Technology and design</td>
<td>2.3</td>
<td>−0.65</td>
<td>n.a.</td>
<td>2.7</td>
<td>n.s.</td>
<td>n.a.</td>
<td>0.52</td>
</tr>
<tr>
<td>Research</td>
<td>2.6</td>
<td>n.s.</td>
<td>n.a.</td>
<td>3.3</td>
<td>n.s.</td>
<td>n.a.</td>
<td>0.88</td>
</tr>
<tr>
<td>Getting a secure, permanent position</td>
<td>3.4</td>
<td>n.s.</td>
<td>n.s.</td>
<td>3.2</td>
<td>0.29</td>
<td>n.s.</td>
<td>−0.31</td>
</tr>
<tr>
<td>Making lots of money</td>
<td>3.1</td>
<td>−0.23</td>
<td>n.s.</td>
<td>2.7</td>
<td>0.37</td>
<td>−0.38</td>
<td>−0.52</td>
</tr>
<tr>
<td>Getting a job immediately after graduating</td>
<td>2.8</td>
<td>n.s.</td>
<td>n.s.</td>
<td>2.9</td>
<td>0.30</td>
<td>−0.43</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

aPositive values indicate that the first-mentioned group scored higher. bMeasures described in TABLE 5. cSingle items.

n.s. non-significant (p<0.01)

n.a. not applicable (the item/construct was not measured for at least one of the groups)

Note. The question was “How important are the following factors for you in a future job?” on a scale from Not important (1) to Very important (4).
Plans for future occupation

Of the 585 secondary physics students, 268 – or 46% – checked the “I don’t know”-box when asked “What kind of a job do you want?” Among the 313 students who gave a written answer, 32% aimed for engineering professions, 31% for health professions, and 18% for non-science occupations. The remaining 18% were spread out on various STEM-related professions and on responses that were hard to define. There was a clear gender pattern: 84% of those aiming for engineering professions were males, and 70% of those aiming for a health profession were females. Of the 278 tertiary physics students, as many as 173 – or 62% – checked the “I don’t know”-box. Of the 101 written responses, 53% referred to research, and the remainder was spread out on various other professions in, almost entirely, science-related fields (e.g. meteorology, alternative energy, petroleum industry). No prominent gender differences were found there.

Priorities in a future job

The question “How important are the following factors for you in your future job?” listed 37 items naming various issues that may or may not be a priority for someone’s choice of occupation. Only a selection of the items is reported here: the four measures idealism, self-realization, technology and design, and research (TABLE 7), in addition to a few single items.

Idealism and Self-realization

All four student groups had high mean scores on the importance of idealism and, in particular, self-realization in a future job (TABLE 7). Female students were more likely than male students to express that idealism was important to them. A similar tendency, but with smaller differences, was found for self-realization, with the exception of tertiary physics students where no difference was found.

Research and Technology and design

Most tertiary physics students responded that being able to do research was important to them in a future job. The secondary physics students were less eager, but not dismissive of the issue. There were also more tertiary than secondary physics students who expressed that working with technology and design was important to them. At both levels, female and male students were equally likely to place high importance on research. In the tertiary physics

‡‡ Examples of non-science occupations mentioned are aircraft pilot, psychologist, economist and lawyer.

§§ Technology and design and Research were not measured for HumSoc and NSEC-students, as the measures were thought to be less relevant for students who had already opted out of a STEM career.
sample, they were also equally likely to want to work with technology and design. At the secondary level, however, this priority was more pronounced among the male students.

*Job security and high income*

Items concerning the importance of job security were endorsed by most students. “Getting a secure, permanent position” had particularly high scores, and somewhat higher than “Making lots of money” and “Getting a job immediately after graduating” (TABLE 7). NSEC students came across as more eager on job security and high income than tertiary physics students.

*Inclinations to choose science-related studies after upper secondary school*

The secondary students answered a question concerning their inclinations towards future tertiary studies in STEM (TABLE 8). Female physics students were more likely than males to agree that they would like to study biology and medicine. Males were more likely to want to study physics, ICT and other technology. There were several statistically significant correlations between the secondary physics students’ inclinations towards further studies and the measures in TABLE 7. Technology and design correlated positively with wanting to study ICT ($r=.54$), other technology ($r=.44$), physics ($r=.30$) and mathematics ($r=.25$), and negatively with wanting to study medicine ($r=-.24$). Idealism correlated positively with wanting to study medicine ($r=.32$) and biology ($r=.27$).
TABLE 8: Inclinations towards tertiary studies – mean scores ($M$) and effect sizes ($d$)\textsuperscript{a}

<table>
<thead>
<tr>
<th></th>
<th>$M$</th>
<th>$d$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Secondary Physics</td>
<td>Females – Males (Sec Ph)</td>
</tr>
<tr>
<td>I would like to study biology</td>
<td>2.1</td>
<td>0.51</td>
</tr>
<tr>
<td>I would like to study physics</td>
<td>2.6</td>
<td>−0.44</td>
</tr>
<tr>
<td>I would like to study chemistry</td>
<td>2.6</td>
<td>n.s.</td>
</tr>
<tr>
<td>I would like to study mathematics</td>
<td>2.8</td>
<td>n.s.</td>
</tr>
<tr>
<td>I would like to study information and communication technology</td>
<td>1.7</td>
<td>−0.47</td>
</tr>
<tr>
<td>I would like to study other technology</td>
<td>2.0</td>
<td>−0.66</td>
</tr>
<tr>
<td>I would like to study medicine</td>
<td>2.8</td>
<td>0.72</td>
</tr>
<tr>
<td>I would like to become a teacher in science or mathematics</td>
<td>1.5</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Positive values indicate that the first-mentioned group scored higher.

n.s. non-significant (p<0.01)

Note. The question was “To what extent do you agree with the following statements about studies after upper secondary school?” on a scale from Disagree (1) to Agree (4).

Discussion

The results enable us to describe what characterizes the motivations, expectations and occupational aspirations of two distinct student groups: secondary and tertiary physics students. Following these descriptions, we discuss how they relate to a physics discipline culture, and go on to discuss implications for improved participation in physics.

The secondary physics students

The secondary physics students expressed that they were highly motivated both by what physics can offer in terms of interest and self-realization, and by its utility value for university admission. Female students were more likely than males to express that utility for
university admission was important for their choice. Several studies have previously reported similar emphasis among physics students on interests (Angell et al., 2004; Hazari et al., 2010; Lyons & Quinn, 2010; Rodseth & Bungum, 2010) and utility for tertiary education (Angell et al., 2004; Lie et al., 2010; Lyons, 2006). In terms of specific sources of inspiration, the secondary physics students gave the highest score to their parents. Responses to the open question about inspiration suggest that parents inspire by fostering interest. Compared to the parents, the teachers were perceived as less inspirational by secondary physics students. In general, the physics students appeared reluctant to ascribe their choices to inspiration from explicit sources (besides their parents). An exception was popular science on television, a source that seemed to have inspired more male than female physics students. Generally, the students appeared to perceive their choices as made independently, based on personal interests and self-realization. This tendency can be understood as a sign of young people’s emphasis on late-modern values such as self-realization and personal meaning, and was also found throughout the entire Lily material by Henriksen et al. (2012).

Although the upper secondary physics students appeared enthusiastic about what they were about to learn and experience in the subjects, the students – females in particular – also expected them to cost a great deal of time and effort. As a group, they expressed a moderate level of self-concept of ability. However, female students were much more likely than males to express concerns about their abilities in the subjects, in accordance with several other studies (Häussler & Hoffmann, 2002; Lyons, 2006; Murphy & Whitelegg, 2006). In a future job, the secondary physics students expressed that they would place high importance on self-realization and idealism, but also on more materialistic concerns such as job security and income. Female physics students were more likely than males to value idealism, and they were less likely than males to see working with technology and design as a priority. These gender differences were reflected in the respondents’ inclinations towards future tertiary studies and careers: Female physics students were more inclined towards medicine, and males were more inclined towards technology and engineering. The results add to a well-established picture of the gender imbalance in physics, engineering, and technology (Dobson, 2007; EU, 2009; NSB, 2010; National Science Foundation, 2006), and to similarly gendered job aspirations among international participants in Programme for International Student Assessment (PISA) 2006 (Kjærnsli & Lie, 2011).
The tertiary physics students

The interest-enjoyment value of physics emerged as a key motivation for tertiary students’ choice to study physics. Compared to NSEC students, they appeared less motivated by utility factors such as job security and high income. The open responses, in particular, suggest that many of them chose physics because of a genuine interest, one that had been triggered and fostered by popular science, teachers and parents. Although parents and other family members were mentioned far less frequently than teachers in the open responses from the tertiary physics students, they have clearly been present in many tertiary physics students’ decisions. Family members – fathers more than mothers – and family traditions were often referred to. Based on the Lily material, Sjaastad (2011) argued that parents helped students define themselves in relation to STEM, and thereby influenced their STEM-related choices.

Tertiary physics students expected to enjoy their study greatly, far more than secondary physics students. This strengthens the impression that tertiary physics students were especially driven by interest-enjoyment. Ulriksen (2010) described how Danish tertiary physics students viewed personal interest to be the most legitimate motivation for choosing physics, in line with the physics culture and ethos. The tertiary physics students also valued a study that would challenge them. Indeed, they appeared to see physics as particularly challenging, expecting the study to cost more time and effort than other study programs. The students appeared, nonetheless, quite confident in their abilities to cope with the work. However, female physics students were much more likely than males to express low self-concepts of ability and to regard the costs of the study as high relative to other study programs. Several other studies have found similar gender differences in students’ self-concept of ability in physics (Lindstrøm & Sharma, 2011; Lyons, 2006; Murphy & Whitelegg, 2006) and their perception of its relative cost (Angell et al., 2004; Duit et al., 2007; Warrington & Younger, 2000).

Like the respondents on the secondary level, the tertiary physics students placed high importance on self-realization and idealism (females in particular) in a future job. They also valued job security and high income, but to a somewhat lesser extent than secondary physics students and NSEC students. Unsurprisingly, the tertiary physics students were more likely than secondary students to value working with technology and design and, in particular, with research. The students’ focus on research was clear also in their answers to the question “What kind of a job to you want?” Gender differences were generally small among tertiary physics students.
Physics – a culture for the interest-driven

“Physicists do it because they love it. […] If you don’t love it, do something else.”

(Lawrence Krauss, 23. Sept. 2011, Public Talk at The Norwegian Student Society, Oslo)

The results presented in this article fall in line with previous research pointing to interests as an important driving force behind choices of physics (Henriksen et al., 2012; Rødseth, 2006; Ulriksen, 2010), and even more so for tertiary than secondary students (Angell, Henriksen, & Isnes, 2003; Reid & Skryabina, 2002). The latter may be a result of tertiary students being more mature and more articulated about their plans for the future. However, the secondary students scored higher on the importance of job security and high income, supporting the notion that there were more utility-driven choices among the secondary physics students, and more interest-driven choices among the tertiary physics students. The tertiary physics students appeared to fit well with the descriptions of the few, but satisfied students in a traditional physics culture dominated by physics content and basic laws (Angell et al., 2004; Danish Evaluation Institute, 2001; Osborne & Collins, 2001). The open responses, in particular, point to a genuine interest, a fascination and curiosity with physics content, as found in popular science and in the physics classroom. Their great expectation of enjoyment did not appear to be threatened by the students’ perception of physics as a study that would cost time and effort. It may be that the characteristics of physics as a difficult and demanding subject (Carlone, 2003; Osborne & Collins, 2001; Tytler, Osborne, Williams, Tytler, & Clark, 2008) and intellectually challenging enterprise (Häussler & Hoffmann, 2000) was not only seen as a cost, but also as a positive feature allowing students to be challenged and to realize their potential.

The secondary physics students placed much importance on the utility value of physics for university admission in their choice. This was not surprising, in the light of the gate-keeping position held by physics in many educational systems, and several other studies have identified utility as a key motivator for choices of physical science (Hutchinson, Stagg, & Bentley, 2009; Lie et al., 2010; Lyons, 2006). In terms of Krogh and Thomsen’s (2005) three purposes of knowledge acquisition (PKA), one could argue that both the absorption- and the conqueror-PKAs were seen in the secondary results. Females were more likely to be motivated by the utility value of physics, as has also been reported in other studies (Bennett & Hogarth, 2009; Miller, Blessing, & Schwartz, 2006). Krogh and Thomsen, however, found that the conqueror-PKA was predominantly held by males, while females dominated among students with a savior-PKA, wanting to learn physics for the purpose of doing good in the
world. Our results indicate that the conqueror- and savior-PKAs coexist among the many secondary physics students – especially females – who planned to use their physics qualification to gain entry to medical school. Nevertheless, female secondary physics students did not appear less motivated by interest-enjoyment than males. They were just as likely as males to be motivated by interest and self-realization, and to expect to enjoy the subjects they had chosen.

How the secondary students actually experienced Level 1 physics, however, the results cannot tell us. The Eccles et al. model (Eccles & Wigfield, 2002) indicates that experiences in the classroom affect the students’ decisions to leave or continue with physics. The tertiary physics students’ frequent mentioning of their teachers as sources of inspiration supports this notion. In a previous study of physics education in Norway, however, the most common reason given by Level 1 physics students for why they would not continue to Level 2 physics, was that they did not need it for further education (Angell et al., 2003). The students who did plan to continue were, not surprisingly, more content with the subject and the teaching than the ‘leavers’. The best-adapted students, the authors argued, were those who complied with the traditional paradigm of physics content and basic laws. Based on our results, therefore, we can hypothesize that it was the most interest-driven and content knowledge oriented among the secondary physics students who continued to tertiary physics studies. They were, perhaps, most likely to comply with a traditional school physics, and most easily acculturated into the physics classroom (Krogh & Thomsen, 2005). One can argue that feeling at home in physics culture requires taking on a physics identity (Aikenhead, 2006; Danielsson, 2009), and that physics will be less attractive to students who perceive the culture and its practitioners to be in conflict with their identity (Eccles, 2009; Hazari et al., 2010; Taconis & Kessels, 2009).

The impression of the tertiary physics students in this study as interest-driven and focused on the subject in itself is strengthened by their desire to do research. Hasse and Trentemoller (2008) argued that the physics culture favors an interest for research and the subject in itself rather than applications. Hazari et al. (2010, p. 17) suggest that only those with a knowledge-based motivation will opt into a physics culture that promotes ‘physics for the sake of physics’ and that a physics community that supported more balanced motivations could be more successful in attracting members of under-represented groups.
Female participation in physics

The female and male tertiary physics students actually gave very similar responses to most questions investigated in this article. For example, they were equally dedicated to future jobs involving research, and to jobs related to technology and design, even though laboratory work and technology have been characterised as masculine practices (Danielsson, 2009). These are encouraging results in terms of retaining the women that have actually chosen tertiary physics. The respondents had just started their study, though, and the discipline culture they met is likely to have been influential in their later decisions about staying in or dropping out of the study. Urry (2008) described the competitive and elitist nature of physics culture and how it may appear alienating – and sometimes discriminating – to females. It is also worth noting in this respect, that concerns about the relative cost of physics and low self-concepts of ability were more frequently found among female physics students than males. A competitive study environment may, therefore, be discouraging for many female physics students. The results in this study cannot answer why self-concept in physics and mathematics is such a persistently gendered issue. According to the Eccles et al. model (Eccles & Wigfield, 2002) gender role stereotypes and young people’s perceptions of these affect students’ self-concepts of ability. It is very likely that cultural stereotypes concerning females’ abilities in these subjects contribute to the gender differences observed in these results.

Small gender differences among tertiary physics students support the notion that the minority of females who choose physics are those who can identify with a traditional, uniform physics culture. However, there was one large gender difference in their priorities in a future job: Female students were much more likely to value an idealistic job. Similar differences were found among secondary physics students, HumSoc, and NSEC students, and have been found in other studies (Krogh & Thomsen, 2005; Schreiner, 2006), which suggests that it is not a physics-specific difference. The written responses of the secondary physics students to the question “What kind of a job do you want?” add to this discussion: 84% of those aiming for engineering professions were males, and 70% of those aiming for health professions were females. In an international comparison based on PISA 2006, Kjærnsli and Lie (2011) studied 15-year-old students’ tendencies to consider a future science-related career. In all the participating countries, males more often than females aimed for careers in physical science and engineering, while females more often than males saw themselves in health professions and life sciences. Eccles (2009) found that valuing helping other people predicted not aspiring to a physical science-related profession. In this sense it was surprising that tertiary physics
students – who to a larger extent than the secondary students had chosen a physics-related career path – valued idealism even higher than secondary physics students. Many tertiary physics students appear to have seen how a physics study may be compatible with an idealistic career path. They have, perhaps, learned about the essential role physics plays in understanding and solving problems related to, for example, climate change, renewable energy, and medical diagnostics. The most ideistically oriented among the secondary physics students appeared, instead, to be aiming for medical studies.

Implications for improved participation in physics

How can participation in physics be improved? First, the results presented here and in the research literature suggest that a good starting point may be to better inform students about the wide range of possible physics-related careers. The present study did not ask directly about the secondary students’ knowledge of career options, but their written responses about their job plans were dominated by references to ‘doctor’/’medicine’ and ‘engineer’, the perhaps largest traditional well-known professions that require physics. That, and the large percentage of secondary physics students who did not know what kind of a job they wanted, indicate that secondary physics has a window of opportunity to introduce the students to a wide range of physics-related career options. One important objective is to inform students better about the variety of interests and priorities that can be met in a physics-related job, and to counteract myths about how physicists work. For example, it is ironic that the stereotypical physicist works alone in a lab, when most physicists actually work in large groups where cooperation with others is essential.

Practically all students in our study expressed that self-realization was important in a future job. They wanted a job where they can use their personal talents and abilities, and develop themselves further. Modern as they may be in this sense, the physics students were not indifferent to materialistic concerns such as job security and income. The need for physicists in the work force should, therefore, be made clear. Also important was the students’ desire to do something that would benefit other people and society, in particular to the female students. To attract more of the Level 1 physics students to physics careers, it may be beneficial to emphasize the role of physics in issues in society that many students care about, and to introduce them to some of the ways in which physics can serve idealistic purposes. Do current secondary physics teachers present many of these and other options to their students? Sjaastad (2011) analyzed the role of significant persons in young people’s choice of higher education based on 5,000 of the Lily respondents, including the tertiary physics sample in the
present study. He found that students in disciplines similar to school subjects – such as physics and biology – were more likely to be inspired by their teachers than students in more applied STEM studies, such as engineering. Our open responses suggest that teachers inspired physics students primarily by stimulating their interests, more than demonstrating the utility value of physics for various careers.

This leads us to the next main implication of our results, namely that more students may want to study physics if the physics culture that dominate in secondary physics classrooms and university physics studies was more inclusive towards students with broader motivations than knowledge-oriented interest alone. Hazari et al. (2010, p. 17) stated that “Anyone who has a physics background or has worked with physicists knows that there is truth to the claim that the physics culture promotes ‘physics for the sake of physics’. […] Others who have additional motivations, like socio-economic concerns, will need to have a passion for physics above and beyond the norm in order to disregard such concerns and opt into physics.” What secondary and tertiary physics students require, however, is clearly not the same. Upper secondary physics students will end up in a wide range of university studies and occupations, and the physics classroom culture they encounter should meet very diverse needs and motivations. Specifically it has to encourage students to learn about a range of applications of physics, as well as basic content knowledge of physics. Tertiary physics studies must to a far greater extent focus on basic content-oriented physics knowledge. However, we argue that also in under-graduate levels in the university should students be able to recognize the many different ways in which physics knowledge may be applied. Many of those who graduate from physics studies end up working as applied physicists. Moreover, society faces important challenges that require solutions by university-trained physicists. Interest is a requirement for successfully completing a university study in physics, but students who are also motivated by the applications of physics or by its importance for socio-scientific issues should be able to identify with the values of the culture – in tertiary as well as secondary education. Strategies that may be beneficial include more emphasis on the role of physics in society contexts, its relation to global challenges, on the many applications of physics, on how it offers challenging opportunities for self-development, and a specific support of females’ self-concept of ability.

It may be particularly challenging to feel at home in physics for students who perceive the subject to be difficult and cost a lot of time and effort, if they have less of the drive from high subject interest. However, other students may be attracted to physics partly because of its
characterization as difficult, because it makes it challenging. Traditional physics culture is endorsed by both teachers and students (Angell et al., 2004), and the suggestion of a change is likely to be opposed. In her study of students in an Active Physics class with an alternative curriculum designed to be accessible to a wider range of students, Carlone (2003) found that some students rejected the class because it was viewed as an easier and less academic physics class, as “blow-up physics”. Can we find a way to make physics more inclusive without losing the most knowledge-oriented students dominated by an absorption-PKA? Physics needs more and different people to develop in new, constructive ways (Schiebinger, 2008), but the field also needs the participants that are driven by their passion for the subject, especially, perhaps, in research where a certain level of absorption is essential.

There is a need for more research on how physics culture may adapt to become more inclusive, on how efforts to do so have worked (for example, Carlone, 2003, 2004), and on how physics teachers and practitioners welcome and/or resist such change. We would also like to know more about how innovative approaches to physics curriculum and instruction may affect students’ interests and willingness to choose physics, and their learning and performance. In Norway there is concern about decreasing performances in mathematics, science and physics as measured by standardized tests (Kjærnsli & Roe, 2010; Lie et al., 2010). Based on results from TIMSS Advanced 2008, Angell, Lie, and Rohatgi (2011) linked the decline in physics competence of Norwegian students to unsatisfactory learning of algebra from previous school years. It is important that measures taken to improve students’ willingness to study physics, also support their learning in physics, to ensure that future students can cope with tertiary physics studies. As an example, The Active Physics class studied by Carlone (2003) did just as well as the Regular Physics class at a basic physics concepts test, even though both students and parents expressed concerns that Active Physics was not rigorous enough.

The under-representation of women in physics suggests that females are less likely than males to be attracted to traditional physics. Many of the characteristics of a typical physics culture have indeed been identified as particularly alienating to female students (Osborne, Simon, & Tytler, 2009; Stadler, Duit, & Benke, 2000; Warrington & Younger, 2000). We do not, however, suggest that interventions to improve participation in physics should target only females. More women are no guarantee that we get more than ‘more of the same’. The point, in our view, is to invite students who do not feel at home in a traditional physics culture, because they are likely to add something to the discipline, both in sheer
numbers and in increased diversity and innovative power. The current under-representation of women and the reports from the research literature, however, tell us that there are more women than men among these students. Thus, a physics culture with a broader appeal is likely to be a more gender-balanced physics as well.

**Limitations**

The present study was not longitudinal, and we do not know how many of the secondary physics students have actually been enrolled into a tertiary physics study, or what characterizes those students. The hypothesis that only the most interest-driven and content-knowledge oriented among the secondary physics students would continue to university physics studies requires further investigation. Another limitation of this study is that interaction effects of gender and field of study have not been investigated. As the four groups of respondents analyzed vary in gender distribution, there may be hidden interaction effects involved in the comparisons made. The aim of giving broad characterizations of physics students led to the study of only main effects on a range of variables, as previous analyses of the upper secondary Lily data revealed few interaction effects (Bøe, 2012). A more pragmatic reason for not including interaction effects was the sheer volume of results in the article, which would have increased substantially.

**Conclusion**

This article has described Norwegian students’ motivations and expectations for choosing physics in secondary and tertiary education. Interests that have been fostered both in and outside school emerged as the primary motivation for both student groups. In addition, the utility value of physics for further education was very important to many secondary students. In terms of improved participation in physics, this indicates that upper secondary physics has a window of opportunity to introduce the students to a wide range of physics-related career options. Among tertiary physics students, a passion for the subject was especially apparent, and the students appeared to fit well with descriptions of traditional physics culture. We have argued that a physics culture that is more inclusive towards students with broader motivations than passionate interest alone, may attract more students to post-compulsory physics.
References


Atkinson, W. (2008). Not all that was solid has melted into air (or liquid): a critique of Bauman on individualization and class in liquid modernity. The Sociological Review, 56(1), 1-17.


Henriksen, E. K., Jensen, F., & Sjaastad, J. (2012). If it's not interesting, then I'm not interested. A survey of how Norwegian science and technology students describe their educational choice. Submitted.


SPSS. (2009). SPSS (Version 17.0). Chicago, IL: IBM.


APPENDICES:

1. Lily questionnaire upper secondary school
2. Lily questionnaire tertiary education (STEM)
3. Errata
This questionnaire contains questions about you and your preferences, expectations and plans related to educational choices. We ask about your choices of subjects and programme area in upper secondary school, and about your plans for further education and future job.

We want to understand your choices, and it is, therefore, important that you answer according to what is important to you. If you don’t understand a question or if none of the alternatives are right for you, you can leave the question blank.

The Lily study is about what you want and what choices you make in upper secondary school, and regarding further education and future job.

Your answers are anonymous – and important to the study! Thank you very much!

1. I am a ☐ Girl ☐ Boy
3. I go to (name of school)
4. Which programme area are you attending?
   ☐ Arts and design
   ☐ Science, mathematics and technology
   ☐ Language, social studies and economics
   ☐ Other: ________________________________
5. When did you decide which programme area to attend?
   ☐ Before or during lower secondary school
   ☐ Between lower and upper secondary school
   ☐ First term of 1st year upper secondary school
   ☐ Second term of 1st year upper secondary school
   ☐ I don’t know
   ☐ At my school one is not able to choose programme areas*  

* If you checked this box we want you to think about your choice of upper secondary school when we ask about your choice of programme area in the rest of the questionnaire.

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6. Which of these courses are you following this year (08/09)?

- [ ] Biology 1
- [ ] Physics 1
- [ ] Earth science 1
- [ ] Earth science X
- [ ] Information technology 1
- [ ] Chemistry 1
- [ ] Mathematics R1 (science)
- [ ] Mathematics S1 (social)
- [ ] Mathematics X
- [ ] Mathematics 2P
- [ ] Mathematics 2T
- [ ] Technology and research studies 1
- [ ] Technology and research studies X
- [ ] Antiquity culture
- [ ] Latin 1
- [ ] Greek 1
- [ ] International English
- [ ] Communication and culture 1
- [ ] Entrepreneurship and development 1
- [ ] History and philosophy 1
- [ ] Marketing and management 1
- [ ] Media and information studies 1
- [ ] Business and industry economics 1
- [ ] Politics and human rights
- [ ] Societal geography
- [ ] Social science
- [ ] Sociology and social anthropology
- [ ] Law 1
- [ ] Community economics
- [ ] Scenography and costume
- [ ] Photo and print
- [ ] Visual culture and society
- [ ] Societal English
- [ ] French II
- [ ] Spanish II
- [ ] German II

- [ ] Other: .........................................................................................

(You do not have to include compulsory courses such as Norwegian, History or Physical Education.)

7. Which of the courses you checked in question 6 do you consider as most important for you? (choose one course)

- [ ] .................................................................

8. To what extent have you been inspired or motivated by the following in your choice of programme area?

<table>
<thead>
<tr>
<th>Source of Inspiration</th>
<th>Small extent</th>
<th>Great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Teachers</td>
<td>□</td>
<td>□ □ □ □ □</td>
</tr>
<tr>
<td>b. Friends and/or boyfriend/girlfriend</td>
<td>□</td>
<td>□ □ □ □ □</td>
</tr>
<tr>
<td>c. Parents or step-parents</td>
<td>□</td>
<td>□ □ □ □ □</td>
</tr>
<tr>
<td>d. Siblings, half-siblings, step-siblings</td>
<td>□ (does not apply)</td>
<td>□ □ □ □ □</td>
</tr>
<tr>
<td>e. Others I know</td>
<td>□</td>
<td>□ □ □ □ □</td>
</tr>
</tbody>
</table>
9. What kind of job do you want? □ I don’t know

10. Can you tell us about an experience or activity that has contributed to your choice of this particular programme area? (leisure activities, TV programs, websites, games, books, magazines, library, museum or science centre visits, specific incidents, teachers or other persons that have made an impression...)

11. To what extent have you been inspired or motivated by the following in your choice of programme area?

<table>
<thead>
<tr>
<th>Small extent</th>
<th>Great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. School counsellor .......................................................... □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>b. “Open days” at upper secondary schools ...... (□ does not apply) .. □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>c. Publicly known people in the media .......................................................... □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>d. Newspapers ........................................................................................ □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>e. Popular science books or magazines .......................................................... □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>f. Other books or magazines ................................................................ □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>g. Posters or advertisements ................................................................ □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>h. Internet ........................................................................................ □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>i. Computer games .................................................................................. □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>j. Museum/science centre ...................................................................... □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>k. Popular science TV channels or programmes (Discovery channel, Newton, Myth busters, Schrödinger’s Katt etc.) ........................................ □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>l. Films and TV series (CSI, West Wing, Numbers, Grey’s Anatomy etc.) □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>m. Nysgjerrigper (magazine, website, etc.) (□ unknown) ...................... □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>n. <a href="http://www.viten.no">www.viten.no</a> .................................(□ unknown) ........................ □ □ □ □</td>
<td></td>
</tr>
<tr>
<td>o. TV commercial about a fireman and a princess (□ unknown) ........... □ □ □ □</td>
<td></td>
</tr>
</tbody>
</table>

Other/comment: ........................................................................................................
12. To what extent have you been inspired or motivated by the following in your choice of programme area?

- www.vilbli.no .................................. (☐ never visited) ...........................................
- www.vigo.no .................................. (☐ never visited) ...........................................
- www.jobbfeber.no .......................... (☐ never visited) ...........................................
- www.velgriktig.no .......................... (☐ never visited) ...........................................
- www.denvirkeligeverden.no ........ (☐ never visited) .............................................
- www.utdanning.no .......................... (☐ never visited) ...........................................
- Upper secondary schools’ websites ..... (☐ never visited) ........................................

13. How important were the following factors for you in your choice of programme area?

- That I would be able to use my talents and abilities .................................................
- That I would be able to develop myself .................................................................
- That I would be able to work creatively ...............................................................
- That I would have fun with the subjects ..............................................................
- That I would be challenged ..................................................................................
- That I would learn about something I am interested in ...........................................
- That I would learn about something I find important and meaningful .................
- That I would learn about something that fits my beliefs and values ....................
- That I would learn about something that is important for society ......................
- My previous marks ................................................................................................
- Entrance requirements for further studies ..........................................................
- To collect as many credits as possible ..................................................................
- To keep many options for further studies open ....................................................
- What my friends chose .......................................................................................
14. To what extent do you agree with the following statements about you and the programme area you have chosen?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Disagree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I am very motivated for the subjects in this programme area ............</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. I am still not sure whether I chose the right programme area ............</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. I will enjoy the programme area I have chosen ................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. The subjects will concern something I find exciting ........................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. The subjects will address issues I find meaningful and important ......</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. The subjects will give me the opportunity to study what I want further</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. I will be proud to have attended this programme area ........................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. It means a lot to me to do well in the subjects ................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. I am cleverer than most students in this programme area ..................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. I am better at these subjects than at subjects on other programme areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. I learn easily in the subjects in this programme area ......................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. I worry that I am not good enough at the subjects ...........................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. This programme area will cost more time and effort than if I had chosen an other programme area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n. I will have less free time than if I had chosen an other study programme</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15. How important are the following factors for you in a future job?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Working with something I am interested in ...................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Using my talents and abilities ..............................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Developing myself ....................................................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Getting a job immediately after graduating ..................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Getting a job where I want to live ..........................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Getting a secure, permanent position ........................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Working in an internationally recognized job community ...............</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Working in an innovative company ............................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Working where something new and exciting happens frequently .........</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Working as part of a team with many people around me ..................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. Working in a good workplace environment ....................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. Working outwardly (information, communication, customer relations)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. Working with something that involves a lot of travelling ...............</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
16. What do you think about mathematics and science as you know the subjects from earlier?  

<table>
<thead>
<tr>
<th></th>
<th>Disagree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Mathematics is more difficult than most other subjects</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. Science is more difficult than most other subjects</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. Mathematics is more interesting than most other subjects</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>d. Science is more interesting than most other subjects</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>e. A good mark in mathematics requires more work than other subjects</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>f. A good mark in science requires more work than other subjects</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>g. I like mathematics better than most other subjects</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>h. I like science better than most other subjects</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>i. Compared to many others I am good at mathematics</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>j. Compared to many others I am good at science</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>k. Mathematics is important and meaningful to me</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>l. Science is important and meaningful to me</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>m. Mathematics is important to society</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>n. Science is important to society</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Other/comment: ........................................................................................................

17. How important are the following factors for you in a future job?  

<table>
<thead>
<tr>
<th></th>
<th>Not important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Helping other people</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. Working with animals</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. Taking into consideration a sustainable development, justice and protection of the environment</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>d. Working with something that is important to society</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>e. Working with something that fits my beliefs and values</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>f. Working with something I find meaningful</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>g. Making my own decisions</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>h. Working independently of other people</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>i. Making lots of money</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>j. Getting TV or media exposure</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>k. Getting leadership responsibility</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>l. Working with something practical and hands-on</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>m. Working with something easy and simple</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
18. **How important are the following factors for you in a future job?**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Developing new knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Doing research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Working creatively</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Designing and creating something new</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Creating something that means something to other people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Having lots of free time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Working with tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Building or repairing something</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Developing technology for renewable energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Developing computer or communication technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. Developing other technology</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other/comment: ........................................................................................................

19. **To what extent do you agree with the following statements about studies after upper secondary school?**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Disagree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I would like to study biology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. I would like to study physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. I would like to study chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. I would like to study mathematics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. I would like to study information or communication technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. I would like to study other technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. I would like to study medicine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. I would like to become a teacher in science or mathematics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other/comment: ........................................................................................................


20. Why do you think
   a. Few young people choose to study technology, physics, mathematics and engineering?
   b. Fewer girls than boys choose such studies?

21. Background information

   a. Mother’s highest level of completed education
      (☐ don’t know/doesn’t apply) ...............................................
   b. Father’s highest level of completed education ....................................
      (☐ don’t know/doesn’t apply) ...............................................
   c. Step-parents’ highest level of completed education
      (☐ don’t know/doesn’t apply) ...............................................

22. Has at least one of your parents/step-parents studied medicine, mathematics, science or technology (e.g. doctor, engineer, technician, researcher or teacher in mathematics, biology, chemistry, physics, technology etc.)?

   ☐ Yes ☐ No ☐ I don’t know

Did you speak a non-Western language at home while growing up?

   ☐ Yes ☐ No Comment: ..............................................................
This questionnaire contains questions about you and your criteria, expectations and plans related to educational choices. First-year students at all Norwegian universities and university colleges are invited to participate.

The research project Vilje-con-valg concerns what young people want – and what they choose when it comes to education and occupation. This information may help us to improve instruction and develop more targeted information for students.

We want to understand your choices, and it is therefore important that you answer according to what is important to you. If you don’t understand a question or if none of the alternatives are right for you, you may leave the question blank. No information will be traceable to you as an individual.

Your answers are important to the study! Thank you very much!

1. I am a  □ Woman  □ Man

2. Year of birth: 19. . . . . . . .

3. I study at (name of university or university college):

4. Degree program:

5. What were your three highest prioritized degree programs in your application for admission through NUCAS* for fall of 2008?
   First priority:  . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
   Second priority:  . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
   Third priority:  . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
   * NUCAS = The Norwegian Universities and Colleges Admission Service

6. Approximately when did you decide on this field of study?
   □ In primary school age
   □ During lower secondary school
   □ During 1st year in upper secondary school
   □ During 2nd or 3rd year in upper secondary school
   □ After upper secondary school
   □ After having studied something else. What?  . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
   □ The decision emerged slowly over a long period of time
   □ I don’t know

The project is run by the University of Oslo. Participation is voluntary. All information is treated confidentially. Because we wish to follow some students through several years, we ask you on the last page whether you are willing to give us your name. In the data analyses, all names will be replaced by a reference number. Questionnaire forms that are returned without names will be anonymized in 2018, and forms with names will be anonymized in 2026. At the end of the project period, this sheet will be destroyed. The project has been reported to the Privacy Ombudsman for Research, Norwegian Social Science Data Services.
7. **Approximately when did you decide to study at this university (college)?**
   - [ ] More than 1 year ago
   - [ ] During the last year
   - [ ] After I was offered a place

8. **Have you taken parts of your primary and/or secondary education (schooling) abroad?**
   - [ ] No
   - [ ] Yes; number of years: …………… Comment: ………………………………………

9. **What is your background?** (you may tick several boxes)
   - [ ] General studies in upper secondary school
   - [ ] IB (International Baccalaureate)
   - [ ] Vocational studies in upper secondary school
   - [ ] Tertiary vocational education
   - [ ] Preparatory course for admission
   - [ ] Adaption through summer course
   - [ ] Local admission

   Other: ……………………………………………………………………………………………

10. **Which subjects did you study in upper secondary school?** (For example 2BIO, 3BIO, 2FY, 3FY, 2MZ/MX, 2SK, 3SK A/B, English2, Law, 2RL, 3RL, vocational studies)
    …………………………………………………………………………………………………………………

11. **Tick the appropriate box if you are enrolled in:**
    - [ ] TRES: three-semester arrangement with summer course
    - [ ] Y-WAY: for applicants from vocational secondary education
    - [ ] Part-time study programme

12. **What further plans do you have for your education?**
    - [ ] One-year study in the program I have chosen
    - [ ] Bachelor’s degree in the program I have chosen
    - [ ] Master’s degree – in which subject? ………………………………………………………
    - [ ] – at what university (college)? ……………………………………………………………
    - [ ] I don’t know

    Other/Comment: ……………………………………………………………………………………………

13. **What kind of job would you like?**  [ ] I don’t know
14. To what extent have you been inspired or motivated by the following in your choice of study programme?

<table>
<thead>
<tr>
<th>To small extent</th>
<th>To great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Teachers................................................................. □   □   □   □</td>
<td></td>
</tr>
<tr>
<td>b. Friends and/or boyfriend/girlfriend................................ □   □   □   □</td>
<td></td>
</tr>
<tr>
<td>c. Parents or step-parents................................................................ □   □   □   □</td>
<td></td>
</tr>
<tr>
<td>d. Siblings, half-siblings, step-siblings ....(□ does not apply)......... □   □   □   □</td>
<td></td>
</tr>
<tr>
<td>e. Other people I know ...................................................... □   □   □   □</td>
<td></td>
</tr>
</tbody>
</table>

does not apply)

15. To what extent do you agree with the following statements?

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. When I applied, I was concerned that the admission requirements should correspond to my grades / grade point average ................... □   □   □   □</td>
<td></td>
</tr>
<tr>
<td>b. I wanted to make use of my grade points by choosing a study programme with the highest admission requirements possible for me... □   □   □   □</td>
<td></td>
</tr>
</tbody>
</table>

16. Please write about your choice of study: Was it hard to choose? Somewhat random? "Always known" that this was what you wanted? A particular incident determined the choice?

17. Imagine an ideal place to study (university or university college) – and tick off for what is most important to you (you may tick more than one box).

□ a. In a big city
□ b. In a smaller place
□ c. Near my home
□ d. Not too near my home
□ e. Large and diverse social environment
□ f. Small and intimate social environment
□ g. Good facilities (buildings, common areas, cafés, library, reading rooms, sports facilities and so on)
18. How important were these factors for your choice of study?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The subjects offered</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. The location of the university (college) in a certain part of the country</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. To study at this particular university (college)</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

19. To what extent have you been inspired or motivated for your choice of study from the following?

<table>
<thead>
<tr>
<th>Source</th>
<th>To small extent</th>
<th>To great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. School counsellor</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. Telephone or e-mail contact with employees at the University (college)</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. Education exposition</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>d. Cinema advertisements for the university (college)</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>e. Information folders from the university (college)</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>f. The Internet pages of the university (college)</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>g. Visit from the university (college) to your school</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>h. Visit to the university (college)</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>i. Visit(s) from companies to your school</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>j. Visit(s) to companies</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>k. Publicly known persons in the media</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

If so, who? Other/comment: ...........................................................................

20. Can you name one or more experiences or activities from your background that have influenced your current choice of education? (leisure activities, TV programs, Internet sites, games, books, magazines, visits to library, museum or science centre, particular events, teachers or other persons who made an impression, or other ….)
21. To what extent have you been inspired or motivated for your choice of study by the following?

<table>
<thead>
<tr>
<th></th>
<th>To small extent</th>
<th>To great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Newspaper articles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Popular science book and magazines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Other books and magazines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. PR posters and advertisements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Internet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Computer games</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Museum/science center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Popular science television channels/programs (Discovery channel, Newton, Mythbusters, Schrödinger’s cat and so on)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Films and TV series (CSI, Numbers, Grey’s Anatomy and so on)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. The national science week</td>
<td>(□ unfamiliar to me)</td>
<td></td>
</tr>
<tr>
<td>k. <a href="http://www.forskning.no">www.forskning.no</a></td>
<td>(□ have not accessed the site)</td>
<td></td>
</tr>
<tr>
<td>l. Nysgjerrigper (magazine, website, competition)</td>
<td>(□ unfamiliar to me)</td>
<td></td>
</tr>
<tr>
<td>m. PR film about firemen and princesses</td>
<td>(□ unfamiliar to me)</td>
<td></td>
</tr>
<tr>
<td>n. Statkraft’s movie with April fools’ joke about star power</td>
<td>(□ unfamiliar)</td>
<td></td>
</tr>
<tr>
<td>o. Aker’s nutcracker films</td>
<td>(□ unfamiliar to me)</td>
<td></td>
</tr>
<tr>
<td>Other/comment:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

22. How important are the following factors for your choice of study?

<table>
<thead>
<tr>
<th></th>
<th>Not important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. High scientific standard of the university (college)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. That the place has a good image and reputation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Good social environment at the university (college)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. That extracurricular student activities are arranged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Personal follow-up from lecturers and advisers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. That you are not clearly under-represented as a girl/boy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. That you have friends, boy/girlfriend and/or siblings at the same university (college)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. That the university (college) has good international student exchange programs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. That the study program opens a range of different job opportunities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. That the teaching is adjusted to your level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. That you are comfortable with your fellow students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. That you are comfortable with the buildings, common areas, cafés,...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. That you see the relevance of what you learn for what you want to work with</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n. That you get challenges and chances for personal development</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comment: ........................................................................................................
23. To what extent do you agree to the following statements about yourself and the degree program you have just started?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Disagree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I am very motivated for this degree program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. I feel certain that I will complete my study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. It may well be that I change my plans during the course of my studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. I am still uncertain of whether I have chosen the right program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. I will be comfortable with the subject area I have chosen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. The program will concern issues I find exciting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. I will have a pleasant everyday life as a student in this program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. The program will concern topics I consider meaningful and important</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. The program opens many good job opportunities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. The program will enable me to choose a job I would like to have</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. I will feel proud of having accomplished this study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. It means a lot to me to do well in my studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. I will be better than most of my fellow students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n. I am better at these subjects than at subjects in other degree programs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o. I learn easily the subjects in this program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p. I worry that I am not good enough at the subjects in this program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>q. My studies will cost me more time and work than if I had chosen an other degree program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r. I will get less leisure time than I would if I had chosen another program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>s. I will have strained economy through my students years</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

24. How important are the following factors to you concerning a future job?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Working with something I am interested in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Using my talents and abilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Personal development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Getting a job immediately after graduating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Getting a job where I want to live</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Getting a secure, permanent job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Working in an internationally recognized job community</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Working in an innovative company or institution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Working where something new and exciting happens frequently</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Working in a team together with other people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. Having a good social environment at the workplace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. Having an extrovert job (information, communication, customer relations)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. Working with something that involves a lot of travelling</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
25. How important are the following factors to you concerning a future job?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Helping other people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Taking into consideration a sustainable development, justice and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>protection of the environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Working with something that is important for society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Working with something that fits my beliefs and values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Working with something I find meaningful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Making my own decisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Working independently of other people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Making lots of money</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Getting TV or media exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Getting leadership responsibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. Working with something practical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. Working with something easy and simple</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. Developing new knowledge and insight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n. Doing research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o. Working creatively</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p. Designing and creating something new</td>
<td></td>
<td></td>
</tr>
<tr>
<td>q. Creating something that means something to other people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r. Having lots of leisure time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>s. Working with tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t. Building or repairing things</td>
<td></td>
<td></td>
</tr>
<tr>
<td>u. Developing technology for renewable energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v. Developing computer or communication technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>w. Developing other technology</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

26. Why do you think
   a) few young people choose to study technology, physics, mathematics and engineering?
   b) fewer girls than boys choose such studies?
27. To what extent have you been inspired or motivated for your choice of study by the following?

<table>
<thead>
<tr>
<th>Website</th>
<th>To small extent</th>
<th>To great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. <a href="http://www.jobbfeber.no">www.jobbfeber.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. <a href="http://www.velgriktig.no">www.velgriktig.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. <a href="http://www.utdanning.no">www.utdanning.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>d. <a href="http://www.utdanningsmagasinet.no">www.utdanningsmagasinet.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>e. <a href="http://www.studiestart.no.no">www.studiestart.no.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>f. <a href="http://www.finnstudie.no">www.finnstudie.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>g. blink.dagbladet.no/utdanning/</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>h. <a href="http://www.denvirkeligeverden.no">www.denvirkeligeverden.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>i. <a href="http://www.norskindustri.no/ung">www.norskindustri.no/ung</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>j. <a href="http://www.gronnboks.no">www.gronnboks.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>k. <a href="http://www.teknovest.no">www.teknovest.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>l. <a href="http://www.utog.no">www.utog.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>m. <a href="http://www.7etg.no">www.7etg.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>n. <a href="http://www.energiutdanning.no">www.energiutdanning.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>o. <a href="http://www.shift.no">www.shift.no</a></td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Other/comment: ..............................

28. Participate in a follow-up study – and get a chance to win an El-Scooter (1 winner drawn) or an iPod Touch (two winners drawn)!

We may wish to get back to you within 3 years with questions about your experiences with your studies, and we therefore need name and contact information. This is voluntary, but by filling out the lines below, you participate in the lottery for the three prizes. (You may withdraw from this survey at any time without giving a reason)

First name and surname: ...........................

Mobile phone no (will NOT be used for spam): ................................

Email (will NOT be used for spam): ................................

In the reports from this survey, it will be impossible to link the results to your name.

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Errata

- p. i, 5th paragraph, line 2:
  “Department of Teacher Training and School Development” changed to “Department of Teacher Education and School Research”.

- p. 2, updated reference for Article II:
  “(2011)” changed to “(2012)” and “DOI 10.1102/sce.20461” changed to “96(1), 1-20”. Reference also updated in citations and bibliographies of thesis and Article III.

- p. 37, 1st paragraph, line 10:
  “Article III” changed to “Article I”.

- p. 51, last reference:

- p. 2 (Article III):
  Heading “The Lily study” and following paragraph deleted.

- p. 14 (Article III), 1st paragraph, line 3:
  “occupation” changed to “educational background”.

- p. 14 (Article III), 1st paragraph, line 5:
  “a STEM occupation” changed to “their educational background in STEM”.

- A few minor spelling or grammar errors have been corrected throughout the thesis.