No man is an island

Significant persons’ influence on young people’s attitudes towards and choice of educations within science, technology, engineering and mathematics

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No man is an island entire of itself;  
every man is a piece of the continent

*John Donne, 1624*
Acknowledgements

As the following pages elaborate on the significance of other persons in one’s life, it is reasonable to expect the author of these pages to recognise and acknowledge his own significant persons. And indeed, they have served as examples of significant persons in the author’s mind throughout the entire writing process. Thus, one might say that the paragraphs that follow are the most thoroughly prepared paragraphs in this thesis.

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Mum and Dad, you somehow seem to know me in ways I do not understand, balancing care and challenges perfectly. The upbringing and values you provided me make you great role models. I continuously make new discoveries of ways that I am like you. And that makes me proud.

Conclusively, although I deserve some credit/blame for the present work, I acknowledge that you all in some way have your fingerprints on this thesis. And now, about to complete 22 years of education, I need to ask the following:

What do I have that is not given to me through other people?

Indeed, I have done my share. But it is not my effort that separates me from an illiterate peer in the favela outside Rio. It is the opportunities created for me by other persons. God has blessed me through you all. I know of no better way to thank you than to pray for you all to experience the love of Jesus.

Jørgen Sjaastad
Oslo, June 2012
Abstract

Considering the crucial role of science, technology, engineering and mathematics (STEM) in promoting sustainable development and a sound economy, concerns about the participation in these subjects have arisen throughout the Western world. In order to increase participation in STEM educations, young people might be inspired by parents, teachers, celebrities and other significant persons – persons who influence adolescents’ attitudes towards STEM. The overall aim of this thesis is to investigate significant persons’ influence on young people’s attitudes towards STEM and choice of STEM educations. Drawing on Woelfel and Haller’s conceptualisation of significant persons, Eccles and colleagues’ expectancy-value model for achievement-related choices, and other perspectives from social psychology, significant persons’ influence is explored in three articles. Different quantitative and qualitative methods are applied in the investigation.

The first article, entitled ‘Sources of inspiration: The role of significant persons in young people’s choice of science in higher education’, draws on questionnaire responses collected in the Lily project, in which 5007 STEM students describe and answer questions about their educational choice. The results here indicate that those who stand in interpersonal relationships with adolescents are of particular importance. The influence of parents and teachers is elaborated on, and the Lily respondents’ descriptions are analysed to expose different ways these two groups of significant persons exert influence; by providing information and displaying STEM subjects and careers, through role modelling, and by contributing to adolescents’ self-knowledge.

The second article ‘Increased motivation for science careers? Investigating a mentoring project’ concerns STEM students who are mentors in the mathematics mentoring project ENT3R. Through focus groups with 15- to 19-year-old participants in ENT3R, aspects of such recruitment initiatives that they appreciate are identified and mentors’ potential influence on the participants’ choice of STEM is discussed. This insight and a pilot study conducted with ENT3R participants form the basis for the third article ‘Measuring the ways significant persons influence attitudes towards science and mathematics’. Here, Rasch modelling is used in the development of a questionnaire instrument measuring the four
modes of significant person influence suggested by Woelfel and Haller’s theoretical framework. The instrument is developed specifically for Norwegian teenagers having STEM students as mentors, but it holds good psychometric properties and is adjustable to other settings and to other recruitment initiatives where significant persons aim at influencing young people’s attitudes towards STEM.

This thesis contributes with overviews and in-depth descriptions of how significant persons might improve young people’s attitudes towards STEM and inspire them to choose STEM educations. Useful terms for discussing interpersonal influence are introduced and exemplified, and an instrument is developed to measure significant persons’ influence on attitudes. It is suggested that parents and teachers might be included in recruitment initiatives to a greater extent. Girls’ and boys’ self-concepts and how they envision typical STEM practitioners are crucial elements influencing their attitudes towards STEM, which points to the importance of personal meetings with STEM practitioners and encouragement from persons who know them well. Celebrities are only credited with a minor influence by STEM students themselves, but it is suggested that significant persons through the media contribute to how Norwegian adolescents perceive different STEM subjects and careers.

Article I

Article II
*Title*: Increased motivation for science careers? Investigating a mentoring project

*Authors*: Jørgen Sjaastad and Fredrik Jensen

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Article III
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Prologue

Mum and MacGyver have something in common. So do my ex-landlord Birgitta, my upper secondary maths teacher Gabriel and Torunn in my church. A director in the Research Council of Norway, Camilla, also belongs to this group, as do Anna who initiated ‘TENK’, athlete Svein Sjøberg and many more. The persons in this oddly composed group have one thing in common: directly or indirectly, they have influenced my educational choices.

At my desk is a gift I received from Joshua Aronson, namely *The Social Animal* written by Joshua’s father and himself. The title is striking. When considered as parts of the animal kingdom, humans are outstanding. Indeed, humans stand out from all other animals in their sociability – they are created to live in interpersonal relationships with God and other humans, making them a unique species on this planet. The undersigned experiences this social nature strongly. My educational choices are the result of interactions with other persons.

‘No man is an island,’ John Donne claimed almost 400 years ago, ‘every man is a piece of the continent’. This thesis is my attempt to elaborate on one of the basic truths of my life.
1. INTRODUCTION
1.1. Aims

In all aspects of life, other persons play significant roles. They influence how we retell our past and how we plan our future. They shape what we do and why we do it. They co-create our worldview and help us find our role in it. All in all; other persons are important in shaping our understanding of who we are.

The influence of other persons is also essential for adolescents as they face many of life’s important decisions: Should I devote myself to politics, sports, environmental organisations, or religion? Who do I want as my close friends? How much effort should I put into school? What kind of education would suit me? What is my place in the greater picture?

The Millennium Development Goals (United Nations Development Programme, 2012) set by the United Nations include eradicating extreme poverty and hunger (Goal 1), improving health (Goals 4-6) and ensuring environmental sustainability (Goal 7). Some of the great challenges faced in the first decades of the 21st century concern hunger, health and environmental issues. In order to meet such challenges and find new solutions for renewable energy, water supply and medical treatments, competence in science, technology, engineering and mathematics (STEM) is necessary. Society needs a sufficient number of people who specialise within these subjects. Moreover, considering the many political issues and everyday challenges that draw on STEM knowledge, these subjects are part of the basic competence needed for democratic participation. If too few persons choose a STEM profession or the public STEM knowledge is insufficient, we need to find ways to inspire young people to engage in these subjects. This does not mean that all adolescents should be persuaded into pursuing a STEM education, but it means that young people should be supported in making well-considered educational choices where STEM might be a real and attractive option.

The decision about education and career is among the most consequential choices young people have to make. In order for them to make well-considered educational choices, they need to learn about themselves, about educations and careers, and the roles the different disciplines play in real-world challenges. As implied by the first paragraph, other persons are also highly significant when it comes to educational choices. Indeed, the influence of significant persons needs to be investigated in order to understand educational choices in
general, to support young people’s decision-making processes, and to secure sufficient participation in STEM. On this basis;

*The overall aim of this thesis is to increase the understanding of significant persons’ influence on young people’s attitudes towards and choice of educations within science, technology, engineering and mathematics.*

Specifically, the following four research questions will be pursued in the articles that constitute this thesis, drawing on data from 15- to 19-year-old participants in a STEM mentoring project and students beginning a tertiary STEM education:

**Research question 1:**
Which significant persons do STEM students regard as important sources of inspiration for their choice of STEM in higher education?

**Research question 2:**
In what ways do parents, teachers and other persons in interpersonal relationships with adolescents inspire choices of STEM educations?

**Research question 3:**
How can the theoretical framework proposed by Woelfel and Haller be applied to investigate the influence of significant persons on attitudes towards STEM and choices of STEM educations, and what are the strengths and limitations of such an approach?

**Research question 4:**
How can the different modes of significant persons’ influence on adolescents’ attitudes towards STEM suggested by Woelfel and Haller be measured through a validated questionnaire instrument?

Small scale and large scale research projects are utilised to answer these questions, drawing on both quantitative and qualitative research methods. Research question 1 is addressed in Article I. Quantitative data is presented in order to get an overview of significant persons’ role in Norwegian STEM students’ choice processes. Research question 2 is targeted in Article I and Article II. The first article elaborates on the role of parents and teachers in tertiary STEM students’ educational choice processes, while the second article concerns
how the mentors in a mentoring project influence the participants’ educational considerations. The first part of Research question 3 is treated in Article I and Article III. In Article I, Woelfel and Haller’s framework is used to structure a discussion about the influence of parents and teachers on educational choice, while in Article III, the framework provides the theoretical constructs that the instrument developed in the article seeks to measure. The second part of Research question 3 is addressed in Article I and implicitly by the results in Article III. Furthermore, this will be specifically addressed in the conclusion of this thesis, drawing on the experiences gained through working with Article I and Article III. Research question 4 is answered in Article III. Drawing on Rasch analysis, the questionnaire instrument is developed in the context of the mathematics mentoring project investigated in Article II. All in all, the targeting of Research questions 1-4 supports the overall aim by providing insight into matters of interpersonal influence on attitudes towards STEM and choice of STEM educations.

As the gender distribution is skewed in many STEM educations and careers, like physics, mathematics, technology and engineering, increasing participation in these subjects to some extent means increasing girls’ and women’s participation. Results indicate that females face more barriers with regard to STEM educations and careers than males. Moreover, research suggests that females tend to rely more on interpersonal relationships in their choice processes. Thus, although there is no explicit gender focus in the overall aim or the four research questions, the gender perspective will appear throughout the thesis.

In answering the four research questions, perspectives from social psychology and principles of measurement derived from psychometrics will be applied. Note that the author is not a social psychologist or a psychometrician. This thesis is regarded mainly as a contribution to science education research. The research presented here merely draws on social psychology and psychometrics in order to target the overall aim. Heightened availability of these perspectives and research methods in science education research might, however, be regarded as a positive spin-off of this thesis.
1.2. Initial clarifications

‘STEM’ and other terms in this thesis

Different expressions and abbreviations are used to encapsulate the subjects, educations and careers that are the focus of this thesis. Expressions that often appear in science education literature are: ‘Science’, ‘Science and mathematics’, ‘Science, technology and mathematics’ (STM), and ‘Science, technology, engineering and mathematics’ (STEM). One might discuss whether or not mathematics is contained in science, technology is contained in science, engineering is contained in technology, and so forth. The T and E are included throughout this thesis primarily because the technological industry and engineering are among the branches where the recruitment situation is most severe. Even though some of the data material in this thesis directly relates to school science and mathematics, these topics are in turn also related to participation in technology and engineering. Thus, to maintain the focus on increased participation also in technology and engineering throughout this thesis, ‘STEM’ will be used consistently.

Notably, concerning the issue of STEM educations in Norway, technology and engineering are not integrated into primary or secondary school as much as some stakeholders would like them to be. While mathematics and natural sciences (physics, chemistry, biology and geosciences) are taught as specific subjects in upper secondary, the application of these subjects to technology and engineering are unknown to many students. Indeed, Norwegian students gain basic competences for technology development and engineering through mathematics and natural sciences. However, the fact that most students have limited knowledge about the relationship between the familiar S and M and the unfamiliar T and E is important to keep in mind throughout the discussion about participation in STEM.

In this thesis, the terms ‘Western world’ and ‘Western countries’ will denote modern, highly developed countries, including the USA, Canada, Australia, New Zealand and European countries high on the Human Development Index (HDI) scale. Due to cultural differences, Asian countries with high HDI, like Japan and Taiwan, are not included unless specified.

The Norwegian education system

All respondents and focus group participants contributing to this thesis are students in Norwegian schools or Norwegian higher education institutions. The educational choices
Ten years of education is compulsory in Norway, namely primary school (1st to 7th grade) and lower secondary school (8th to 10th grade). Following normal progression, compulsory education begins the year children turn six and is completed the year they turn 16. Up to this point, most students have the same curriculum. Upper secondary school, which is free and accessible to all, lasts three years (11th to 13th grade) and is usually undertaken within the year a student turns 19. About 90% of Norwegian youth start upper secondary school. According to recent figures, 54% of these choose vocational training and 46% choose general studies (Norwegian Directorate for Education and Training, 2012, p. 4). Thus, the first decision point is the year one turns 16. The next decision point is at the end of the first year of upper secondary, the year one turns 17, when students in general studies choose a specialisation for the following two years of upper secondary. In Norway, about 40% of the students in general studies choose natural science and mathematics specialisation (ibid., p. 14). This specialisation is compulsory in order to access a STEM education after upper secondary, implying that choices taken at the age of 15/16 and 16/17 are decisive for the opportunity to study STEM. Notably, there are some other ways to access higher educations within STEM for those who choose vocational training or specialisation in subjects other than natural sciences and mathematics. This normally takes one or two years of additional academic training.

The students who complete upper secondary school receive university admission certification. Most public universities and university colleges in Norway offer three-year bachelor programmes and two-year master programmes, and some also offer five-year integrated master programmes. Many STEM educations presuppose full specialisation in mathematics and a physics course from upper secondary, and some educations require certain marks. The admission fee to public higher education institutions is about $100 per semester. Practically speaking, education is free in Norway. About 30% of 19- to 25-year-olds are enrolled in higher education, of which about 37% study mathematics, science and technical subjects (Statistics Norway, 2010).
1.3. Participation in STEM

The recruitment situation in STEM

The overall aim of this thesis concerns the influence of significant persons on young people’s attitudes towards and choice of educations within STEM. The interest is this matter is partly driven by the acknowledgement of STEM practitioners’ decisive role in society and the importance of scientific literacy. The United Nations’ Millennium Development Goals (United Nations Development Programme, 2012) demand a workforce that is competent in science and technology, which is essential for communication systems, agricultural technology, medical treatments, renewable energy, and so forth. A knowledge-based industry is also essential to promote economic stability and growth (EU, 2010). Moreover, as many political issues in different ways involve technological solutions and insight into natural sciences, a scientifically literate public is fundamental in well-functioning democracies (Levinson, 2010). The STEM training gained through school is essential in promoting democratic participation, and many professionals need more than the compulsory training. Conclusively, the workforce, both nationally and globally, needs a certain number of persons who specialise in STEM subjects in upper secondary school and in tertiary education. On this basis, there has been a growing concern among science education researchers, industry and policy makers about the participation in STEM educations. The current recruitment situation in STEM will be reviewed briefly in the following paragraphs. A more thorough description of this situation is provided by Bøe, Henriksen, Lyons and Schreiner (2011).

The proportion of 15- to 16-year-olds choosing A-level physics in the UK was halved from 1990 to 2008 (Joint Council for Qualifications, 2012). So was the proportion of students in first-year university science courses in France from 1995 to 2007 (Arnoux, Duverney, & Holton, 2009). These two examples, one from upper secondary school and one from tertiary education, illustrate a major trend: the general, relative decrease in participation in mathematics subjects and physical sciences at different educational stages. STEM enrolment numbers have been reported to decline throughout the Western world, for instance in Europe (OECD, 2008), Australia (Lyons & Quinn, 2010), the USA (Stine & Matthews, 2009) and Canada (Government of Canada, 2007). The decline varies according to which specific STEM subject, which country and which educational stage is investigated, but most
figures have had a relative decrease over the last decades. As a result, both industry and the education system will face a lack of qualified personnel in the years to come. For instance, there is a predicted shortage in the number of practitioners for most engineering disciplines (United Nations, 2010) in countries like Germany, the UK and Norway (Kaspura, 2010). Moreover, there are not enough qualified physics and chemistry teachers in countries like the Netherlands, Denmark and Norway (Osborne & Dillon, 2008).

In the Norwegian case, the recruitment challenge is acute in schools. Firstly, many science and mathematics teachers do not have the necessary competence. Science teachers at the 8th grade have less education than the international average in relevant subjects (like biology, chemistry, physics and geosciences) and mathematics teachers have less education in mathematics than the international average (Gronmo & Onstad, 2009). Secondly, the predicted shortage of science and mathematics teachers in upper secondary is dramatic. In 2008, 36% of the advanced mathematics teachers and 26% of the advanced physics teachers were 60 years or older, and ‘recruitment among young teachers is far from sufficient to cover this deficit’ (Gronmo et al., 2008, p. 40). Not surprisingly, a severe lack of science and mathematics teachers in Norwegian upper secondary schools was reported three years later (Union of Education Norway, 2011).

Turning to the gender issue, research suggests that a gender balanced work environment promotes both the quality of research (genSET, 2010) and social well-being in the workplace (Holter, Svare, & Egeland, 2008). Moreover, engaging women in STEM might empower and enrich their lives (Bøe et al., 2011). For these reasons, concerns about the gender diversity are voiced by science education researchers and policy makers (Bøe et al., 2011; Norwegian Ministry of Education and Research, 2009). The documented under-representation of women in mathematics, physics, engineering and technology applies to all stages of STEM educations (Dobson, 2007; EU, 2009). Ability parameters do not explain why women choose STEM educations to a less extent than men. Only small differences in boys’ favour in mathematics and no consistent differences in science were identified in the international PISA study (OECD, 2010b), and a meta-analysis of research on gender differences in mathematics and science abilities concluded that boys and girls practically speaking have similar cognitive abilities (Hyde & Linn, 2006). The overrepresentation of boys in the top 5% of the mathematics ability distribution has decreased over the last 30 years (Wai, Cacchio, Putallaz, & Makel, 2010), which is too fast for evolutionary changes to
take place. This suggests socio-cultural influences not only on enrolment patterns, but also on selected ability parameters. Conclusively, gender differences found in enrolment patterns are only explained by differences in ability to a small extent. Socio-cultural factors are suggested as main contributors to the skewed gender participation in STEM (Ceci, Williams, & Barnett, 2009). Even though they have similar abilities, addressing these factors is important, as young persons’ perception of their own abilities influence educational choice (Eccles et al., 1983). Moreover, an actual – and not merely formal – free choice of education includes freedom from stereotypes and traditions that constrain choices.

Three issues will be mentioned here to provide a more nuanced description of the current participation in STEM. Firstly, the global financial crisis led to a sudden decrease in the personnel demand in certain STEM industries and an increase in university enrolment (Sursock & Smidt, 2010). This shift is, however, assumed to be temporary and the participation trends prior to the crisis are most likely to reappear (OECD, 2010a). Secondly, the recruitment situation varies between countries (Bøe et al., 2011), for instance with regard to the gender distribution and the STEM branches that experience the most acute lack of professionals. Thirdly, the STEM recruitment challenge does not include all STEM subjects. Life and health sciences like biology, biochemistry and pharmacy do not share the recruitment challenges of the ‘mathematics loaded’ STEM subjects. In fact, university enrolment in life and health sciences is considered sufficient to meet the future demand (OECD, 2008). The issue addressed here will still be referred to as ‘recruitment to STEM’ due to the common use of this term. In this thesis, as it is written in a Norwegian context, the STEM recruitment challenge particularly concerns recruitment of science and mathematics teachers and increased participation in mathematics, physics, engineering and technology. Moreover, women are heavily underrepresented in these particular fields in Norway.

Conclusively, estimations for Western countries predict a lack of STEM practitioners in the near future. Fortunately, as this thesis is being completed, the Norwegian government report ‘record numbers for candidates in science and technology’ (Norwegian Ministry of Education and Research, 2012). Specifically, the total number of persons who completed three- or five-year educations within engineering, technology, or other educations within mathematics and natural sciences in 2011 was higher than in any of the ten foregoing years. In fact, project Lily – which this thesis is a part of – is mentioned in the governmental press
release as one of the efforts that contribute to this increase. However, the recruitment challenge has not come to an end, as expressed by Tora Aasland, who was Secretary of State until March 2012: ‘There is still a great need for engineers and others with STEM educations in the society’ (ibid., my translation). Thus, participation in STEM still needs to be improved at all stages in the educational pathway, from 15- to 16-year-olds’ first choice of specialisation in school to the choice of tertiary education. The untapped potential is great, especially among girls and women.

**STEM recruitment efforts**

Most science education researchers, educational institutions, industry, and policy makers agree that low participation in STEM is a matter of concern, and many stakeholders have initiated or taken part in efforts to increase participation (e.g., Barmby, Kind, & Jones, 2008; The RENATE Centre, 2011). However, despite the great number of recruitment efforts, the number of research articles concerning the effect of these is quite small. In investigating research reports on this matter, Jensen and Henriksen (2010) concluded that ‘the most striking result from this search is that there exists comparatively little in the way of research in this area’ (p. 42). One reason for this might be the common belief identified by Fenwick-Sehl, Fioroni and Lovric (2009), who surveyed participation and retention projects at universities in Canada. They claim that ‘there is general belief (among faculty staff) that all efforts have had positive outcomes’ (ibid., p. 33), which might have reduced their interest in spending time and resources on investigating and improving these efforts.

Moreover, due to the complex process leading up to an educational choice, there are methodological challenges in establishing direct effects of recruitment projects. This is why most researchers apply probabilistic terms in evaluating recruitment efforts, that is, most researchers point to *increased probability* of STEM choices rather than direct effects of these efforts (e.g., Swimmer & Jarratt-Ziemski, 2007; Vollstedt & Wang, 2006).

Fortunately, many researchers can point to such increases. For instance, Dabney and colleagues (2011) investigated the effect of out-of-school science activities drawing on survey data from about 7000 students enrolled in introductory English courses at 34 different universities in the USA. They found that participation in projects providing STEM experiences was positively related to career interest in STEM at university, and they concluded that the effect of these efforts was increased probability of having career interest in STEM.
Many similar results are reported from different recruitment efforts. The Dutch network Jet-Net collaborates with upper secondary schools to provide students with STEM activities, and they report an increase in the number of students choosing a STEM profile in these schools, relative to schools not involved in the project (Smits, 2009). Barmby, Kind and Jones (2008) investigated the Lab in a Lorry project, where a mobile laboratory visited 11- to 14-year-old students in school. The students were unanimously positive and reported that they had become more interested in science. In the ESTEAM project in Wisconsin (Woolston, Zaki, & Winter, 1997), high-achieving students with an interest in engineering were invited to a day-long campus visit. They received information, were engaged in hands-on activities, and got to meet engineering students. Evaluations showed that two thirds of the students had become more certain that they would pursue an engineering education at this institution. Also aimed at high-achieving STEM students in lower and upper secondary school, the international Olympiads in physics, chemistry and mathematics create interest in STEM educations. Guttersrud and Angell (2002) investigated the educational paths of former Norwegian participants in these contests. About 60% of them claimed that their participation had influenced their educational choice.

Chun and Harris (2011) investigated six STEM recruitment efforts, aimed primarily at girls. These efforts included afterschool modules, recreational activities, summer camps and mentoring projects. Drawing on this investigation, Chun and Harris suggested five strategies for STEM recruitment efforts aimed at girls, which are also assumed to be beneficial for boys. One of these was to focus on building personal relations. The importance of this is pointed to by Cantrell and Ewing-Taylor (2009). They investigated an intervention where 11th and 12th grade high school students in the USA attended eight weekly sessions where STEM practitioners presented their careers. This was highly appreciated by the students, and they reported to have learned about many careers they did not know existed. However, even though the career presentations were regarded as successful, Cantrell and Ewing-Taylor conclude that the social hours following the presentations provided the most powerful experiences. The students got to interact with the STEM practitioners in an informal setting and got to ask about what it was like to have STEM as a living. The importance of personal relations in STEM recruitment efforts is also highlighted in Article II in this thesis, where the mentoring project ENT3R is investigated. In this project, students from 15 to 19 years old come to their local university or university college for weekly ‘maths trainings’ led by tertiary STEM students. Focus groups were conducted with
participants in ENT3R. Some of them clearly expressed that the mentoring project had increased their interest in STEM educations, and some reported that they had changed their specialisation in upper secondary school due to ENT3R. Moreover, the project has been evaluated by SINTEF, the largest independent research organisation in Scandinavia. SINTEF concluded that about 50% of the participants enjoyed mathematics more and about 60% considered tertiary STEM educations after participating in the project (Haugsbakken & Buland, 2009).

Finally, Kopp, Hulleman, Harackiewicz and Rozek (2012) provide an example of an intervention involving parents. Girls and boys in 10th and 11th grade from 108 different schools in the USA were selected and randomly assigned to treatment or control groups. Over the next 15 months, the parents of students in the treatment group received two brochures containing information about the value and importance of science and mathematics courses. Moreover, the brochures provided guidance on how to discuss such topics with adolescents. Finally, the parents were invited to evaluate the recruitment campaign website. This increased their exposure to information aimed at inspiring parents to promote science and mathematics courses at home. According to Kopp, Hulleman, Harackiewicz and Rozek, students in the treatment group pursued significantly more courses in science and mathematics in their last two years of high school. Thus, including parents in target groups of recruitment initiatives might be an efficient way to increase participation in STEM.
1.4. Thesis overview

This thesis centres on three articles concerning significant persons, attitudes towards STEM and participation in STEM. The five chapters preceding the articles are written in order to elaborate on important issues and to put the articles into a broader context. In the Introduction (Chapter 1) the overall aim and research questions are stated and participation in STEM is described, serving as a backdrop for the overall aim. Following this introductory chapter, Theory and existing research that informs this thesis is presented in Chapter 2. The perspectives from sociology and social psychology used throughout the thesis are presented. Finally, Chapter 2 presents existing science education research that concerns attitudes towards STEM, participation in STEM and interpersonal influence.

The different Methods utilised to collect and analyse data are described in Chapter 3. Open-ended and closed Likert scale questionnaire items and focus group interviews provide the data material upon which the three articles are based, and validity issues are discussed in this respect. Chapter 3 also includes an introduction to Rasch analysis, which plays a major role in the third article. This introduction is aimed at persons without prior knowledge of Rasch analysis.

A Summary of the three articles is provided in Chapter 4. Finally, Chapter 5 is devoted to a Discussion where the results are put into broader contexts. Significant persons in general and the particular influence of parents, teachers and persons in the media are discussed. Drawing on the limitations of this work, suggestions for future research are presented, and implications for persons seeking to increase young people’s participation in STEM are given. Finally, the overall aim of this thesis is revisited and conclusions are drawn.
2. THEORY AND EXISTING RESEARCH
2.1. A sociological viewpoint

What do you want to be when you grow up? It seems many potential fire-fighters and princesses have answered this particular question. However, sociologists Illeris and colleagues (2002) suggest that the question should be ‘Who do you want to be when you grow up?’ – indicating that educational choice is closely linked to identity and other persons. Indeed, the educational choice is not made in a vacuum. Significant persons play an important role, and culture, tradition and social sets provide the conditions under which significant persons influence young people. Thus, some sociological theories concerning youth in the Western world might provide a backdrop for the forthcoming discussions.

Obviously, young people are diverse, and counterexamples exist for any statement given about them. Some critics point to the level of abstraction in the theories to be presented below, and other critics point to examples of how the characteristics of our time, drawn by sociologists, are exaggerated (e.g., Blackman, 2005). These objections will not be treated here. The theories are still useful as starting points for understanding to whom the significant persons discussed in this thesis are significant, namely young people in the Norwegian society and similar societies in the Western world at the beginning of the 21st century. The following paragraphs are based on Schreiner’s (2006) introduction to these theories.

Youth in Norway and the Western world

The birth and growth of the welfare state have provided Norwegian youth with great security. As for the educational setting in Norway, the economic and formal freedom is undisputable. Public schools guarantee everyone 13 years of schooling, possibly leading to a university admission certification. With the proper grades from upper secondary school, all tertiary educations are accessible regardless of background. Anyone who attends a university or university college education receives governmental financial support.

With regard to educational choice, Norwegian youth consider themselves to be free from constraints from family, tradition and expectations from others. This is part of what Beck, Giddens and Lash (1994) describe as detraditionalisation, where the roles of tradition and authorities are weakened. Being patient, hard-working and obedient is not valued as highly as seeking pleasure and fulfilling desires (Schreiner, 2006). Young people are no longer
willing to serve the system (Eckersley, 2002). They have the freedom to prioritise themselves, and careers are perceived as sources of personal satisfaction (Inglehart, 1997).

Sociologist Anthony Giddens claims that we are ‘what we make of ourselves’ (1991, p. 75). The self is regarded as chosen and constructed. However, Giddens claims that the self also contains something given and stable. Young people have to be ‘true to themselves’, fulfilling what is latent in their self. In fact, ‘the ethic of individual self-fulfilment and achievement is among the most powerful currents in modern society’ (Beck & Beck-Gernsheim, 2002, p. 22). Young people feel that they betray their selves if they attend activities they experience as monotonous and tedious (Schreiner, 2006). Experiences and activities are sought only if they are ‘meaningful to me’ (Frønes & Brusdal, 2001, p. 113, my translation). Thus, young people have a dual experience of the self-fulfilment process: they are free to do whatever they want, but they view themselves as serving a naturally given self. In particular, due to the major role played by careers in the lifespan, the educational choice has to be coherent with other facets of the self. Self-fulfilment cannot be achieved if the outcome is a biography with major internal inconsistencies. ‘The individual must […] connect future projects with past experiences in a reasonably coherent fashion’ (Giddens, 1991, p. 215). The process of self-fulfilment overlaps with the identity project, which will be discussed in the social psychology section. The identity project is particularly evident in the youth phase (Coleman & Hendry, 1999) and it interacts with the continuous stream of everyday choices of appearance, activities and beliefs. The evolving identity supports decision-making, while the sum of everyday decisions partly defines the identity. Lyng (2004) describes how young people in Norway also define and communicate identity in classroom contexts, through performance, preferences and behaviours. How they relate to science and mathematics is in many ways implied by their identity, and conversely, their identity is in part defined by these relations.

Conclusively, young people in the Western world experience great freedom to strive for self-fulfilment and to choose educations that enhance the self-fulfilment process. External constraints like tradition, authorities and economy are weakened. The major constraints are internal, as girls and boys have to be true to themselves and exhibit coherence. Thus, young people are left with great responsibility. They have no one but themselves to blame for unwanted outcomes of different choices. While previous generations experienced stronger constraints with regard to education and career, provided by family tradition, neighbourhood
subculture and social class, Western adolescents are now left with few clues concerning choice of education. In a situation where choices are overwhelmingly abundant, the opportunity to make a familiar and secure choice might become more attractive. Choices suggested by or similar to those of trusted persons step up as good options. This is probably part of the reason why many educational choices can be traced back to students’ background. Empirical studies indicate that family background, notably parents’ education and socio-economic status, is correlated with educational participation and success (Schnabel, Corinne, Eccles, Köller, & Baumert, 2002; Turmo, 2003). Thus, significant persons can be of great significance for Western youth, even though they often reason in highly internal ways when choices are explained (Holmegaard, Ulriksen, & Madsen, 2012).

STEM careers: ‘Important but not for me’

The ROSE project aimed at describing 15-year-old girls’ and boys’ attitudinal and affective perspectives on STEM in education and society (Schreiner & Sjøberg, 2004). About 40 countries took part in this project, which has resulted in a great number of publications (Sjøberg, 2011). Project leaders Sjøberg and Schreiner, among others, claim that the values and interests of young people are important determinants of educational choices (Sjøberg & Schreiner, 2010).

A main conclusion of ROSE is that youth in Norway and many other Western countries value science highly without wanting to work in science themselves. On one hand, they agree with statements like ‘Science and technology are important for society’ and ‘Science and technology make our lives healthier, easier and more comfortable’. On the other hand, Norwegian youth – girls in particular – respond negatively to statements like ‘I like school science better than most other subjects’ and ‘School science has opened my eyes for new and exciting jobs’. They do not want to become scientists and they do not want to work in technology development. However, they want to work with something ‘I find important and meaningful’, where they are ‘Using my talents and abilities’ and ‘Making my own decisions’. Schreiner and Sjøberg conclude that ‘their education and their future job have to be interesting and meaningful, to harmonise with their identity and to open up opportunities for self-actualisation and self-development’ (2007, p. 241). Results from project Lily (Schreiner, Henriksen, Sjaastad, Jensen, & Løken, 2010) show that these requirements are stable: students beginning a tertiary education agree with the 15-year-olds.
Conclusively, girls and boys in the Western world perceive STEM as important, but many of them do not perceive careers in STEM as interesting or meaningful. The 10- to 11-year-old girls and boys in Archer and colleagues’ (2010) research distinguished between ‘doing science’ and ‘being a scientist’: they enjoyed doing science but did not want to become scientists. ROSE researchers in many Western countries support this conclusion, and Jenkins and Nelson (2005) published the results from England under a title pinpointing Western youth’s general attitude towards science: ‘Important but not for me’.
2.2. Social psychology

The necessity of social psychology research

After World War 2, research about ‘The American Soldier’ was presented. Paul Lazarsfeld (1949) stated six major findings, for instance that soldiers from rural districts were in better spirits during army life than soldiers from the city – perhaps not a surprise, the former soldiers being more accustomed to hardships than the latter. Moreover, better educated soldiers suffered more adjustment problems than other soldiers. Again the finding makes sense, since being street-smart is a greater advantage in battle than being a complex-minded intellectual. The fact that many researchers spend time and money to reveal facts that most of us know all along is often commented upon. Lazarsfeld was aware of this. In fact, later in his article about the American soldier, he revealed his little scheme: all of the six results he presented were the direct opposite of the actual results. He claimed that if the true results had been presented first, these would also have been labelled as ‘obvious’. City people are more used to working in crowded conditions and in corporations with lines of command, and better educated people are more used to handling mental stress. Lazarsfeld concluded that there is a need for social psychology research:

\[\text{Since every kind of human reaction is conceivable, it is of great importance to know which reactions actually occur most frequently and under what conditions.} \]
\[\text{(Lazarsfeld, 1949, p. 380)}\]

Aronson, Wilson and Akert define social psychology as ‘the scientific study of the way in which people’s thoughts, feelings and behaviours are influenced by the real or imagined presence of other people’ (2010, p. 3). This thesis considers how significant persons play important roles in young people’s attitude development and educational choice processes. Most readers will recognise that they have experiences confirming the results presented here. However, it is likely that opposite claims could have been confirmed through experience as well. In line with Lazarsfeld’s statement, there is also a need for research on significant person influence. Thus, frameworks and perspectives from social psychology will be used in this thesis for the purposes of the overall aim.

At the core of this thesis is Woelfel and Haller’s (Haller & Woelfel, 1972; Woelfel, 1968, 1972; Woelfel & Haller, 1971) conceptualisation of significant persons. They developed the
Significant person framework drawing on symbolic interactionism, which is an important tradition within social psychology. The definition of significant persons provided by Woelfel and Haller includes some of the major topics in social psychology, namely interpersonal influence, the self and attitudes. These three topics will be discussed in the following pages, starting with interpersonal influence, which will be introduced in the presentation of symbolic interactionism.

Similarities might be identified between symbolic interactionism and constructivism. Many science education researchers are familiar with constructivism (Osborne, 1996), which Colburn (2000) labels the ‘grand unifying theory’ in science education. According to constructivists, knowledge is constructed in a person’s mind, affected by experiences and existing viewpoints. Ultimately, ‘what we hold to be true will be based on what “works” for us’ (ibid., p. 9). This perspective has many similarities with symbolic interactionism.

**Symbolic interactionism**

*Interacting and continuously changing humans*

Traditional symbolic interactionism is most commonly traced back to the sociologist and psychologist George Herbert Mead (1863-1931), who took up the ideas of William James and Charles Horton Cooley. In 1890, James wrote *Principles of Psychology* where he claimed that a man ‘has as many different social selves as there are distinct groups of persons about whose opinion he cares’ (1890, p. 294). He elaborated on the importance of other people in understanding one’s self. The closeness of self and other was taken one step further by Cooley, who famously stated that ‘self and other do not exist as mutually exclusive social facts’ (1902, p. 126). He emphasised that no consistent view of the self could make it distinct from other people and described the *looking-glass self*: we imagine other persons watching our appearance and their judgement of our appearance, and we are left with feelings that influence our self-development.

James and Cooley anticipated ideas that Mead came to incorporate in his works, later collected in *Mind, Self, and Society* (1934) and labelled symbolic interactionism. Mead’s philosophical viewpoints highly influenced his work, and Charon (2010) presents Mead as a pragmatist. He emphasised that one’s actions are influenced not by how the situation actually is, but by how one perceives the situation; how it is defined, interpreted,
experience, and makes sense in the moment. Indeed, a person’s thoughts about becoming an engineer are not influenced by how engineers really are, but by how the person thinks they are.

Symbols are the building blocks of the symbolic interactionists’ world. In fact, most human actions consist of symbolic elements (Charon, 2010). We do and say things according to what we believe are shared understandings of these actions and words; what they symbolise to the other person in the situation. Words – meant to represent concrete objects, concepts, or ideas – are basic and crucial symbols. As for all symbols, these are socially developed, implying that different people might have more or less different understandings of these. Thus, since symbols are used ‘for the purpose of giving off meaning that he or she believes will make some sense to the other’ (ibid., p. 50), all persons taking part in the situation must use symbols taking other persons’ understanding of these into account, constructing and reconstructing the symbols as the interaction unfolds.

According to symbolic interactionists, the process of thinking takes actions into interactions, which means that ‘actors take one another into account, symbolically communicate to one another, and interpret each other’s actions’ (ibid., p. 138). That is, individuals constantly influence one another in an interactive context. They define and redefine the situation and their role in it based on other actors’ use of symbols. Although the perspective of symbolic interactionism is mostly applied to social phenomena, a striking and physical example of this influence is provided by the Emperor in the story about the Emperor’s new clothes: he walks out naked not based on reality as it is, but based on reality as defined by him in interaction with the two sneaky weavers. His interpretation of a little boy’s words and the crowd’s mumbling, however, makes him perceive the situation differently.

Two important aspects of symbolic interactionism will be pointed to here. Firstly, this viewpoint rejects humans as passive beings. They act and interact, they define and redefine. Secondly, through interaction, individuals symbolically communicate who they are and how they perceive others. Exemplifying these two implications, young people’s educational choices are actively developed, drawing on how they define and redefine themselves and the educations. Moreover, these choices are symbolically communicating how they define themselves; what they value, what they believe they are good at, how they would like to be perceived, and so forth. The educational choice develops over years in interaction with other
persons, who symbolically communicate how they perceive the individual and different educations and careers. Parents, science and mathematics teachers, peers and STEM celebrities all take part in the process of shaping an educational pathway.

**Interacting and changing – yet constrained and stable**

Developed from traditional symbolic interactionism, *structural symbolic interactionism* (Burke & Stets, 2009; Sewell, 1992; Stryker, 1980, 2008) suggests that there are constraints on human interaction in general and persons’ self-definitions in particular. It is proposed that interactions create and refine a social structure over time (Stryker, 1980, 2008). This structure is thoroughly discussed by Sewell (1992), and drawing on this discussion, Shanahan and Nieswandt view social structure as ‘underlying patterns, expectations, and norms that influence relationships and behaviour within social groups’ (2011, p. 368). Stryker (1980) claims that all actors’ thoughts and behaviours are constrained by the expectations of others, structuring the interpersonal interaction.

Structural symbolic interactionism thus presents a viewpoint of the self in the social world where interpersonal influence is essential. In interaction with others persons, symbolic activity helps the focal individual develop a sense of self, as it is continuously redefined by all actors in the situation. Despite the fact that they are all continuously developing and active actors, structural patterns develop in these interactions, where others’ and one’s own expectations constrain the situational pathway. These structures influence the way an individual’s self is developed.

**The self in social psychology**

Social psychologist Baumeister writes aptly about the self and how we tend to think about it in the Western world: ‘It is often regarded as having a vast hidden component, so that other people cannot perceive or understand your “self” unless you reveal it to them, and indeed even you might have to struggle and work hard in order to know your own self’ (1999, p. 2). In pondering about ‘who I am’, related and overlapping concepts like ‘self’, ‘roles’ and ‘identity’ might appear. The self will be introduced here as a starting point for an introduction of roles, stereotypes and identity.

Mead (1934) elaborated on how humans are able to treat themselves as objects, that is, to see themselves from the outside and to reflect upon themselves. This ability is a core
element in Leary and Tangney’s definition of the self: ‘The self is a mental capacity that allows an animal to take itself as the object of its own attention and to think consciously about itself’ (2003, p. 8). Social psychologists frequently discuss the origin and development of self-concepts, and Fiske (2010) organises these processes into four categories. Firstly, self-perception of behaviour (Bem, 1972) takes place when persons observe their own behaviour as outside observers would do, as the talented mathematics student who pictures himself solving complex challenges. Secondly, introspection takes place when persons analyse their own thoughts and feelings in order to learn about themselves. For instance, young people might ask themselves, ‘Do I really enjoy this subject?’ Thirdly, Fiske highlights the information gained from comparisons with other people. Social comparison theory (Festinger, 1954) has played a major role in this research. Through such comparisons ‘people confirm their attitudes and perceptions through interpersonal comparisons with the attitudes and perceptions of similar other people’ (Hogg, 2003, p. 466). For instance, Taconis and Kessels (2009) suggest that choice of science partly depends on a comparison of oneself to the prototype science student. Fourthly, the self-concept develops through social feedback. Interactions with other people provide feedback in the form of statements, reactions, gestures and unintended behaviour. Many actors might influence whether a girl perceives herself as suitable for a STEM education.

The self is commonly viewed as being multifaceted. Higgins (1987) proposes the actual, ideal and ought selves, being representations of attributes you believe you actually possess, attributes you ideally would like to possess, and attributes you believe others expect you to possess, respectively. Furthermore, Markus and Nurius (1986) describe the possible self, which in some ways encompasses all the selves proposed by Higgins. This self includes hopes, fears, fantasies and goals for the individual. This self is, as all other selves, highly influenced by other persons, and is assumed to be directly related to previous social comparisons: ‘What others are now, I could become’ (ibid., p. 954). Exemplifying some of these selves, a science teacher giving positive feedback on an assignment might influence the actual self of a young girl. The ideal self might be influenced by a person hosting a science show, causing a desire to become a great science populariser. Her parents might (unintentionally) communicate that they expect their daughter to follow in their footsteps and pursue a university degree in science, thus influencing her ought self. All these selves might contribute to the construction of a possible self; she now imagines herself as a student in science communication.
Roles and stereotypes

Mead noted how ‘we are one thing to one man and one thing to another’ (1934, p. 142). The idea that persons play different roles in different settings is commonly accepted. ‘Roles’ are defined in different ways, but most definitions describe roles as some kind of collections of personal and interpersonal elements: it is ‘a cluster of traits’ (McClelland, 1951, p. 293), ‘a set of norms that define how people in a given social position ought to behave’ (Myers, 2002, p. 137), and ‘the behaviour expected of a person who fills a certain socially defined position’ (Fiske, 2010, p. 180). For instance, the science student role might include words like ‘intelligent’ and ‘interested in natural phenomena’. Roles are of great utility in social life as they provide scripts for the general and the specific behaviour related to certain social positions (McClelland, 1951). According to structural symbolic interactionists, a probabilistic approach to these scripts is fruitful: roles are examples of social structures created through repeated patterns of interaction, but these patterns are reproduced to a varying extent in different groups and contexts (Shanahan & Nieswandt, 2011). That is; a science student might very well convince his peers that he is disinterested in natural phenomena. In this thesis, roles will be defined according to structural symbolic interactionists Burke and Stets, who state that a role is ‘the set of expectations tied to a social position that guide people’s attitudes and behaviour’ (2009, p. 114). Shanahan and Nieswandt (2011) investigated the expectations Canadian 10th grade science students experienced due to their role as science students. The researchers identified four main clusters of expectations related to the science student role: ‘Intelligence […], being and acting scientific […], being skilled in science […], and behaving well in class […’] (ibid., p. 20).

Notably, there are several ways to be a science student, and the singular ‘science student role’ is thus slightly misleading. As for the science students in the example above, most persons are subject to expectations inferred from the social groups to which they belong (Fiske, 2010). That is; some expectations are ascribed all persons in a social group and do not necessarily guide behaviour. These constitute stereotypes, defined as ‘a generalisation about a group of people in which certain traits are assigned to virtually all members of the group, regardless of actual variation among the members’ (Aronson et al., 2010, p. 391). Stereotyping occurs instantly and unconsciously (Macrae & Bodenhausen, 2000), and persons in other groups are often perceived as being more homogeneous than the groups oneself belongs to (Fiske, 2010). Changing these images is challenging, as most stereotypes
are highly resistant towards contradictory information (Macrae & Quadflieg, 2010). Thus, it might take many examples of sociable and nice mathematics students to convince adolescents that stereotypical images of mathematicians are incomplete.

Not only do stereotypes influence how one perceives other persons; they also influence the persons within the stereotyped groups. Stereotype threat has been demonstrated in a variety of situations (e.g., Alter, Aronson, Darley, Rodriguez, & Ruble, 2010; Steele, 1997; Steele & Aronson, 1995) and refers to the immediate and measurable negative effects of being reminded of stereotypes in a testing situation. If reminded of a group one belongs to, the fear of confirming a negative stereotype about this group relevant to the task at hand disrupts task-relevant cognitive processes, thus lowering the performance. A classic example is of women taking mathematics achievement tests. According to gender stereotypes, women are not as good as men in mathematics. Reminding women of their gender prior to a mathematics test might cause them to expend cognitive capacity dealing with the threat of confirming the gender stereotype. This, in turn, negatively affects their achievement, confirming the very stereotype that caused it. Some persons choose disengagement and domain avoidance to elude these situations (Steele, Spencer, & Aronson, 2002). This effect might, for instance, contribute to decrease girls’ participation in STEM.

Knowledge about roles and stereotypes stem from different sources. Many of these are described in Albert Bandura’s (1977) social learning theory. This theory has been highly influential in social psychology and draws on processes described in symbolic interactionism, namely ‘a continuous reciprocal interaction of personal and environmental determinants’ (ibid., pp. 11-12). Put simply, social learning happens by observation and imitation of other persons. Symbols are shared in interaction, and ‘images of desirable futures foster courses of action designed to lead toward more distant goals’ (ibid., p. 13). Drawing a link via Markus and Nurius’ (1986) possible self, this might illustrate the effect of role models. Considered as a subgroup of significant persons, which will be elaborated on later in this chapter, role models provide knowledge about different roles accessible for persons holding different social positions. This, in turn, might foster images of oneself taking on different roles, such as the young girl who sees a female weather forecaster and imagines herself as such, thereby including ‘meteorologist’ in her possible self.
Identity

Turning to identity, Fiske suggests that ‘identities are all different roles that people have’ (2010, p. 189), and Charon suggests that ‘identity is really a process; who we are is an ongoing development’ (2010, p. 144). In light of structural symbolic interactionism, these two definitions might be viewed as complementing each other. The self enables the individual to engage in interaction where roles are negotiated, and identity might thus be viewed as a snapshot of the ongoing process of role negotiation – the sum of all roles the self claims at a certain point in time.

The identity process is closely related to self-presentation, defined by Fiske as a person’s attempt ‘to convey certain identities or images to other people’ (2010, p. 181). Self-presentation is not necessarily a superficial or manipulative activity; it might rather be an attempt to portray an accurate self (Schlenker, 2003). Other persons contribute to this process through social validation, that is, other persons’ recognition of who we are is essential to our identity. This recognition might be communicated through words and actions, and the persons close to an individual might validate certain aspects of ‘who you are’ frequently and over time. For instance, ideas about which educations might be suitable develop over years through interaction with other persons (Holmegaard et al., 2012), and parents, siblings, friends and teachers hold particular opportunities to exert a strong influence.

Summarising the perspectives on the self, roles and identity presented here, the self is the agent; the thinking and acting ‘you’ that reflects upon yourself. Through self-perception, introspection, comparisons and social feedback, the self-concept is formed; everything you know and think about yourself. Roles are sets of expectations tied to social positions, and these are ‘out there’, defined and developed in interaction. The self claims some of these roles in constructing an identity. The identity, which is the sum of all roles a person takes, is how the self is expressed to the surroundings.

The attitude concept in social psychology

The attitude concept is at the core of Woelfel and Haller’s (1971) definition of significant persons, which is utilised in this thesis. Gordon Allport famously defined attitudes as a ‘mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual’s response to all objects and situations with which it
is related’ (1935, p. 810). Several theorists focus on attitudes as ‘responses’ (e.g., Fishbein & Ajzen, 1975) and evaluative components (e.g., Eagly & Chaiken, 1993; Myers, 2002). A major distinction between the many different definitions of attitudes is the varying emphasis put on affect, behaviour and cognition – the ABC of attitudes (e.g., Fiske, 2010; Myers, 2002). Put simply, affect concerns the emotions and feelings raised by the attitude object, behaviour concerns the actions (or absence of actions) related to the object, and cognition concerns knowledge, beliefs and thoughts about the object. Woelfel and Haller’s definition of significant persons draws on a definition of attitudes that emphasises the cognitive aspect.

Researchers, notably those who do not define attitudes in terms of behaviour, have conducted correlation studies of attitudes and observed behaviour. These studies often reveal a mismatch; attitudes are not necessarily good predictors of behaviour (Myers, 2002). This is exemplified in the sociology section in this thesis, where Western youth seem to have positive attitudes towards STEM without wanting to engage in it themselves. Attitude change does not necessarily imply behavioural change. Fostering positive attitudes towards STEM merely increases the **probability** of a STEM educational choice.

**Attitude formation**

Being a core subject of social psychology, several theories exist on how attitudes emerge and develop. For instance, the *mere exposure effect* (Zajonc, 1968, 2001) makes people favour what they have been frequently exposed to. Parents talking frequently about certain science topics might cause this effect. Classic experiments by Sherif (1937) and Asch (1956) point to the power of **conformity**. This is evident through the tendency of attitudes to converge in a group, like how a group of peers tend to share the same opinion about their mathematics teacher. *Direct experience* with the attitude object also plays an important role in creating and changing attitudes. In fact, the attitudes formed this way tend to correlate highly with behaviour, possibly due to the easy access through memory (Fazio, Powell, & Herr, 1983). Providing adolescents with hands-on experiences might thus be a powerful way to influence their attitudes, for example through experiments and meetings with STEM professionals.

The attitudes of those with whom one frequently interacts are learned most thoroughly; parents, siblings, friends and teachers are important contributors. However, symbolic modelling through TV and the Internet has provided new arenas where models are observed.
Thirty-five years ago, decades before adolescents began to spend time on the Internet, Bandura wrote that increased media consumption has ‘greatly expanded the range of models available to children and adults alike’ (1977, p. 24). He claimed that ‘with increasing use of symbolic modelling, parents, teachers, and other traditional role models may occupy less prominent roles in social learning’ (ibid., p. 39). Thus, a wide range of persons might take part in attitude development, and these are all included when Woelfel and Haller define significant persons.

**Woelfel and Haller’s conceptualisation of significant persons**

About 40 years ago, Joseph Woelfel and Archibald Haller led ‘The Significant Other Project’. Through this project they developed The Wisconsin Significant Other Battery (WISOB), which consisted of different questionnaires aiming at identifying significant persons and measuring their influence on young people’s educational and occupational plans (Haller & Woelfel, 1969). WISOB was developed with a focus on significant persons’ expectations as predictors for educational choices. The WISOB was a forerunner for what later became the ‘Galileo Method’, which is now used by industry and governments in the USA to measure cognitive processes (Galileo Company, 2011). Even though Woelfel and Haller’s WISOB is not commonly known by social psychologists nowadays, their work provided a conceptualisation of significant persons that might be applied to investigate how other persons influence attitudes in general and young people’s relationship to STEM in particular.

Note that Woelfel and Haller use the term ‘significant other’. In some countries, this term is now used to denote a romantic or sexual partner. To avoid confusion, the term ‘significant person’ is used throughout this thesis, and the original term will only appear in direct quotations. Notably, Woelfel and Haller were not the first to describe ‘significant others’. The development and use of this term in social psychology will be presented before turning to their definition.

**Significant persons in social psychology and symbolic interactionism**

The term ‘significant other’ is commonly credited to symbolic interactionist Mead. Certainly, the idea of significant person influence is in line with the symbolic interactionist ideas of both Cooley and Mead. However, Mead described the ‘generalised other’, claiming that the self is partly constituted by ‘an organisation of the social attitudes of the generalised
other or the social group as a whole to which he belongs’ (1934, p. 158). It is in Harry Stack Sullivan’s *Conceptions of Modern Psychiatry* from 1940 that the term appears for the first time. Sullivan uses the concept to describe the persons with major influence on the social self, writing in a later version of the book that the self ‘is built largely of personal symbolic elements learned in contact with other significant people. [...] The point is that the self is approved by significant others’ (1953, p. 46). The difference between Mead’s and Sullivan’s concepts has been interpreted as an indication of a shifting world: ‘In Sullivan’s time, and ours, the community has been fractured. The generalised other has broken down into clusters of significant others’ (Cottrell & Foote, 1952, pp. 190-191).

Woelfel and Haller interpreted Sullivan’s significant persons as ‘those persons who are particularly influential in the formation, support or modification of the self-conceptions (or attitudes) of an individual’ (Haller & Woelfel, 1969, p. 15). The fact that they are ‘particularly influential’ suggests different degrees of influence, elaborated on by structural symbolic interactionist Stryker who claimed that ‘in a fragmented and differentiated world [...] in order for action to proceed, the individual must give greater weight or priority to the perspectives of certain others’ (1967, p. 377). Charon summarises the symbolic interactionist understanding of significant persons as:

> [...] those people who take on importance to the individual, those whom the individual desires to impress; they might be those he or she respects, those he or she wants acceptance from, those he or she fears, or those with whom he or she identifies. [...] Whoever our significant others are at any point in our lives, they are important precisely because their views of social objects are important to us, including, and especially, our view of ourselves as social objects. [...] In a sense, I fail to see myself without my awareness that these significant others see me. (Charon, 2010, p. 75)

Today, the term ‘significant other’ is not frequently used, but social psychologists talk about ‘those around you who exert influence’ (personal communication, Kvalem, 2009). Psychologists Andersen and Saribay define the term as ‘individuals who have been influential in their lives’ (2005, p. 1), which is a definition that is ‘about as careful as most try to be’ (personal communication, Baldwin, 2010). Woelfel and Haller’s definition is slightly bolder.
The definition of ‘significant persons’ used in this thesis

In structural symbolic interactionism, individuals are viewed as interacting and continuously changing, constrained by stabilising expectations and norms. Their perceptions of the world, as opposed to the actual reality, are decisive for their interactions. Through these interactions, identities are negotiated and roles are abandoned and adopted. Attitudes, including affective, behavioural and cognitive components, develop in interaction and contribute to how the individual relates to attitude objects like ‘scientists’, ‘mathematics classes’, and ‘STEM careers’. In the following paragraphs, Woelfel and Haller’s definition of significant persons will be stated and elaborated on. These paragraphs are based on four articles written in the late 1960’s and early 1970’s (Haller & Woelfel, 1972; Woelfel, 1968, 1972; Woelfel & Haller, 1971).

As an anticipatory definition, significant persons are the ‘persons who exercise major influence on the attitudes of individuals’ (Woelfel & Haller, 1971, p. 75). In describing attitudes, Woelfel and Haller hold up two main components: the person holding the attitude and the attitude object. With regard to participation in STEM, science education researchers have also utilised this twofold, as when Reiss and colleagues claim that ‘participation in such subjects depends at least in part on how students see both themselves and the subjects’ (2011, p. 274). Woelfel and Haller define attitudes as a person’s conception of the relationship between his conception of self and his conception of the attitude object. In this context, a conception of an object might be regarded as a cognitive summary of everything the individual knows about the object, weighting differently certain experiences and pieces of information. The conceptions of the self and the attitude object are compared and constitute a new conception: ‘my attitude towards this object’. The importance of including the self-concept in the attitude might be exemplified by two persons who regard physics courses as being ‘difficult’. The first person might regard himself as being ‘too laid-back for hard work’, and might thus have a different attitude towards physics educations than the second person, who regards himself as ‘enjoying a challenge’. That is; different attitudes can result from the same information due to different self-conceptions.

Conceptualising significant persons in terms of their influence on attitudes, Woelfel and Haller’s definition is derived from how they define attitudes. They describe the term slightly differently in their articles, and drawing on their works, I define significant persons the following way in this thesis:
A significant person is a person who either through direct interaction or by example provides information that influences the focal individual’s conception of himself or the focal individual’s conception of the attitude object.

The fourfold of significant persons

A 2 × 2 structure regarding significant persons might be derived from this definition. Firstly, a significant person might influence an attitude either by influencing the conception of self or the conception of the attitude object. Moreover, Woelfel and Haller draw on Harold Kelley’s (1952) work with ‘reference groups’, where those who hold expectations of the person are differentiated from those who serve as examples for behaviour. In line with this, they suggest two ways to exert this interpersonal influence; through direct interaction or by example. Significant persons who do this are called definers and models, respectively. In Woelfel and Haller’s 1971 article, the distinction is drawn between those who use words and those who provide examples, while in their 1972 article, the distinction is drawn between those who communicate via direct interaction and those who are observed by the individual. Conclusively, definers ‘communicate norms, expectations, or other self- or object-defining information to an individual through interaction’ (Haller & Woelfel, 1972, p. 594), most commonly using words. Models are observed by the individual and ‘stand as points of cognitive reference but do not [necessarily] interact with the subject’ (ibid., p. 594), providing examples of the attitude object or being examples of a self in relation to the object. Conclusively, Woelfel and Haller’s definition provides four different ways to exert influence as a significant person:

Defining the self: Providing attitude relevant information about the focal individual’s self through direct interaction.

Defining the object: Providing information about the attitude object through direct interaction.

Modelling a self: Providing an example of a self in relation to the attitude object.

Modelling the object: Providing an example of the attitude object.

Note that in the ‘defining the self” and ‘modelling a self” definitions, the phrases ‘attitude relevant information’ and a self ‘in relation to the attitude object’ are used, respectively.
Someone convincing a person that she is a terrific ice skater probably does not influence her attitudes towards scientists. Neither does the comedian on TV, who is modelling a self, but who does not relate to science at all. ‘[...] Interpersonal contact is likely to produce change in beliefs, attitudes, intentions and behaviours [...] only when participants come in contact with a relatively large number of individuals who are clearly identified as members of that group’ (Fishbein & Ajzen, 1975, p. 417). The TV comedian might, however, influence the person’s attitudes towards comedians, modelling a role as a comedian. Role models are considered as a subgroup of significant persons, being persons who model a self in relation to an object. In the previous section, roles were defined as sets of expectations that guide people’s attitudes and behaviour. A role model will simply be defined here as a person who displays a certain role in relation to an attitude object. This might be a role close to the stereotype, or it might be an unfamiliar and new role. Moreover, the role might be appealing or unappealing, opening up for ‘negative’ role models.

Exemplifying the fourfold of significant person influence, imagine the 16-year-old girl Maria who is about to choose specialisation for upper secondary school. Throughout her childhood, her mother has encouraged her to do her science homework and has constantly been asking her about what they are learning in science class. The mother’s interest has led Maria to look at herself as someone who ought to perform well in science. Thus, the mother has helped Maria define her self. Two weeks ago, Maria’s older friend Jessica shared her experiences with the mathematics course given in Maria’s school, helping Maria to define the object. However, as she considers choosing mathematics, Maria comes to think of John, who is the top geek in her class. He is definitely going to choose mathematics and she does not look at herself as one of ‘these guys’. He has modelled a self in relation to mathematics that does not appeal to her. Still, Maria chooses to pursue the science and mathematics specialisation in upper secondary, based on her newborn interest in cell biology. Her teacher engaged her in some amazing biology experiments this semester. Through modelling the object this way, this teacher strongly influenced her attitudes towards science and mathematics. Now, Maria tells her friends that she will choose science and mathematics specialisation ‘because I’m interested’.
A theoretical example: Eccles and colleagues’ model

Eccles and colleagues’ expectancy-value model for achievement-related choices

A model will be introduced here that seeks to explain achievement-related choices, like the choice to participate in STEM. Eccles and colleagues’ expectancy-value model (Eccles et al., 1983; Eccles & Wigfield, 2002; Wigfield & Eccles, 2000) is a social psychology model suggesting different factors that influence achievement-related choices. For instance, Bøe, Lyons, Henriksen and Schreiner (2011), Jacobs and Bleeker (2004), and Schau (2003) have all utilised the model to investigate adolescents’ participation in STEM. The model draws on a vast amount of empirical research and includes many factors. In fact, except for choices that are considered random, most factors explaining the choice to pursue an education or a career might be expressed within this model. Bøe and colleagues (2011) argue that the model provides a useful framework for discussing choices to pursue or not to pursue STEM educations. Eccles and colleagues’ model informed the leaders of project Lily (Schreiner et al., 2010) in developing the questionnaire on which the first article of this thesis is based. Moreover, it was the starting point for the interview guide used in the focus group interviews in the second article in this thesis, and results from this investigation were presented within the framework of this model. Below, the model will be introduced and utilised to exemplify how Woelfel and Haller’s framework concerning significant persons’ influence on attitudes might be linked to a model explaining educational choice.

According to Eccles and colleagues’ model, choosing to engage in a task depends on whether or not individuals believe that they can master it and on how individuals value it. That is; individuals’ motivation for engaging in a task is explained by their expectation of success and the subjective task value they ascribe to the task. These two factors are, among other things, shown to predict career choices (Eccles, Barber, & Jozefowicz, 1999). Students are more likely to choose a STEM education if they believe they can succeed and if they give personal value to this choice. Expectations of success and subjective task values, which will be described in the following paragraphs, depend on psychological, social and cultural patterns, taking the socialisers and the individual’s milieu into account (Figure 1):

Expectation of success is closely related to Bandura’s (1986) self-efficacy and concerns how well persons believe they will do on an upcoming task. The person considers the chances of succeeding, completing, or performing well, and success is relatively understood: A low-achieving student might regard completing a course as a success, while a high-achieving student might regard anything but the top grade as a failure.

The subjective task value consists of four components: how the task is subjectively valued depends on 1) the interest-enjoyment value, 2) the attainment value, and 3) the utility value the individual relates to the task, together with an evaluation of 4) the relative cost of engaging in the task. The interest-enjoyment value, closely related to intrinsic motivation (Ryan & Deci, 2000), considers the person’s interest in the activity and the enjoyment the person experiences when engaging in it. Will I have a good time doing this? Is this something I am interested in and think is fun? The attainment value concerns how important it is to the person to do well on such a task and is closely related to identity (Eccles, 2009). Does this establish or confirm who I am? Does it fit my identity? Is it important to me? The utility value a person attaches to a task depends on the person’s external goals, and this is related to extrinsic motivation (Ryan & Deci, 2000). Will I benefit from engaging in this
with regard to other goals I have? Will this activity bring me closer to something else I want?

Eccles’ model proposes that increasing the interest-enjoyment, attainment or utility value a person attaches to a task will make it more likely that the person chooses to engage in it. The opposite is true for the fourth subjective task value, namely relative cost. This concerns the person’s considerations of the negative aspects. How much will it cost me in terms of time and effort? Will I have to quit other activities, reduce my social life, or let go of any other dreams I have? How will I feel if I fail?

Throughout this thesis, in discussing various ways that significant persons influence attitudes and educational choices, much of the content in the ‘Cultural milieu’, ‘Child’s perceptions’ and ‘Child’s goals and general self-schemata’ boxes (Figure 1) will be considered. Eccles and colleagues’ thus ascribe significant persons with great importance for educational choice: significant persons influence expectation of success and the subjective task values, which in turn directly influence the educational choice.

**Linking Woelfel and Haller’s framework and Eccles and colleagues’ model**

The four modes of significant person influence suggested by Woelfel and Haller might be linked to the terms in Eccles and colleagues’ model. Firstly, a significant person defining the self might raise a person’s expectation of success through encouragement (‘You can do this’), and the attainment value might be increased through holding expectations (‘You have always been the smart one in our family’). A significant person defining the object might lead the person to ascribe greater utility value to the task through information about different careers (‘Engineers are well-paid’) and greater attainment value by connecting a particular subject to something that is important to the person (‘This education is perfect for creative people’). Through modelling a self, a significant person might reduce the relative cost perceived by the person by showing that a STEM student has time for social activities, and the expectation of success might be heightened by letting the person see that ‘someone like me is able to do this’. Finally, a significant person modelling the object might raise the interest-enjoyment value the person ascribes to the task by engaging the person in activities related to the education, and the perceived utility value might be raised through the significant person’s demonstrations of technology that improves people’s lives – which is the major career goal for this person.
Social psychology: A summary

Throughout this section, core motives in social psychology have been introduced. Social psychology considers how our lives are influenced by other persons, and the perspective taken by structural symbolic interactionists is that of humans as continuously acting and changing. This activity is based on a continuous redefining of self, others and the world. It takes place in interaction with other persons, it draws on shared understanding of symbols, and it is constrained by shared expectations that structure the interaction. The self reflects upon itself and draws on knowledge gained in interaction. Roles are abandoned and adopted, stereotypes are confirmed and countered, identities are negotiated and communicated, and possible future selves are suggested and developed. All of these interpersonal activities, related to roles, stereotypes, identity and possible selves, are key elements when discussing why young persons choose to study or not study STEM.

Specifically, attitudes develop through interaction with other persons, influencing how a person affectively, behaviourally and cognitively relates to physical or abstract phenomena. These other persons who influence attitudes might be called significant persons. Woelfel and Haller suggest that they, through direct interaction (defining) and by providing examples (modelling), might influence a person’s conception of self or the person’s conception of the attitude object. Drawing on terms from Eccles and colleagues’ expectancy-value model for achievement-related choices, examples can be provided of ways that significant persons influence young people’s attitudes towards and choice of educations within STEM.
2.3. Research in science education: attitudes and significant persons

Science education researchers continually shed light on youth’s participation in STEM, and many ways to inform, inspire and engage girls and boys have been proposed. Significant person influence is one piece of a great puzzle, and a variety of insights from science education research are relevant when discussing significant persons. Some of the relevant literature on attitudes, how images of science and scientists fit young people’s identities, and gender issues will be reviewed here. Finally, some existing science education research on significant persons will be presented.

There is a vast array of definitions and conceptualisations describing role models, heroes, and other influential persons in science education literature. The authors referred to in the following paragraphs use these concepts differently. In the forthcoming section, the different authors’ precise definitions will not be important in order to grasp the main ideas. Thus, the terms in this section will be used somewhat inconsequently.

Keep in mind that the main target group in this thesis is young persons at educational decision points; typically 15- to 19-year-olds choosing specialisation subjects throughout upper secondary and entering tertiary education. Nonetheless, research with target groups spanning from young children in primary school to young adults in tertiary education will be included here, as the early years are important in the development of attitudes towards STEM and the young adults’ reflections might provide useful insight into educational choice. Moreover, some of the reviewed research concerns attitudes towards STEM, some concerns choice of STEM, and some concerns achievements in STEM. Although the focus of this thesis is on the two former factors, significant persons’ influence on STEM achievements is assumed to influence attitudes and choice. This might be justified by the direct and indirect influences of STEM achievements on many of the components in Eccles and colleagues’ expectancy-value model for achievement-related choices (Eccles et al., 1983) and by how Woelfel and Haller (1971) describe attitude change. For instance, achievements might heighten the expectation of success, reduce the relative cost of having to work hard in the subject, and increase the interest-enjoyment value through positive mastery experiences. Furthermore, concerning Woelfel and Haller’s descriptions, achievements might influence one of the two major components of attitudes, namely the self-conception.
Attitudes towards STEM and choice of STEM educations

Attitudes towards STEM

Osborne and colleagues (2003; 2009) argue that a decline in youth’s participation in STEM must be understood through an investigation of their attitudes towards STEM, defined as ‘feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves’ (2003, p. 1053). This view has been held by science education researchers for at least four decades. Already in 1968, a ‘swing from science’ was identified in the UK (McPherson, 1969), leading Gardner (1975) to give his description of existing science attitudes a few years later. In broad outline, science education researchers have concluded that young people’s attitudes towards STEM are in fact quite positive. For instance, the 15-year-olds in the 40 ROSE countries mainly agree that ‘science and technology are important for society’ (Sjøberg & Schreiner, 2010, p. 6), and in the 2006 PISA study it was concluded that more than 90% of 15-year-old students considered science to be important for understanding the world and improving people’s lives (OECD, 2007).

Even though the main attitudes towards STEM are positive, there are reasons for concern. Positive attitudes towards STEM seem to decline in the early teenage years (Osborne & Dillon, 2008). For instance, Bennett and Hogarth (2009) show a significant decline in the appreciation of science lessons and the interest in science careers from the age of 11 to 14. Furthermore, even though most of the 15-year-old PISA students considered science as important, only 57% agreed that science is very relevant for them personally (OECD, 2007). Notably, there is a distinction between science and school science as attitude objects (Barmby et al., 2008). Many students experience school science as transmissive, disconnected from the real world and with no room for discussions (Bøe et al., 2011; Lyons, 2006). There is ‘a clear disparity between the students’ notions of science [...] and that presented by school science’ (Osborne et al., 2003, pp. 1060-1061). Many researchers call for action in school science (e.g., Osborne & Dillon, 2008). Schreiner and Sjøberg (2010) suggest that school science might focus more on aspects the ROSE participants highlight as important in future jobs, like environmental aspects and people-oriented issues. Rahm (2007) suggests that teachers might treat STEM as cultural productions, displaying its dynamic, social and cultural aspects. This is in line with Aikenhead (1996, 2001), who suggests learning STEM as culture acquisition, including social, historical and philosophical
aspects of science. Lemke (2005) suggests that students might be taught about the persons who do science and why they do it, drawing the link between role models and attitudes towards STEM. Many research results contribute to the ‘strong confirmatory evidence for children’s and adults’ anecdotal stories about the influence of teachers on students’ attitudes to school science and on subject choice’ (Osborne et al., 2003, p. 1068). The results concerning teachers are supported by Article I in this thesis, where tertiary STEM freshmen’s experiences with inspiring teachers are described. Many of these students attribute science and mathematics teachers with great influence on their educational choice.

Image of science and scientists
Mead and Métraux (1957) famously described how scientists were perceived among high school students in the 1950’s: as white males wearing glasses and white laboratory coats, spending most of their time alone in the laboratory mixing chemicals. The picture drawn of scientists about half a century later is – both metaphorically and literally speaking – strikingly similar (Cakmakci et al., 2011; Sjøberg, 2002). For instance, the 9- to 14-year-olds in Koren and Bar’s (2009) research confirm this. Through interviews, written text and drawings, images similar to the old stereotypes appeared among the Hebrew-speaking children. Notably, the Arabic-speaking children described scientists more like the stereotype in non-Western countries, where scientists are portrayed as intelligent heroes helping other people (Anderson, 2006; Sjøberg, 2002). The method of collecting drawings to investigate the image of scientists has been criticised. Losh, Wilke and Pop (2008) point to methodological shortcomings in such investigations. Despite this, they conclude in line with other researchers that ‘these drawings suggest that scientists do suffer an “image problem” that develops early among children’ (ibid., p. 789). This image problem might ultimately influence attitudes towards STEM and participation in these subjects.

Besides the scientists, the STEM subjects might also suffer an image problem. If the physical sciences have a masculine image, this might be an explanatory factor for the shortage of girls. If STEM is perceived as difficult, this might lead students with low self-efficacy to choose other subjects, whereas the image of STEM as something fixed with no room for questions or one’s own ideas might lead those away from STEM who perceive themselves as creative. Unfortunately, Kessels, Rau and Hannover (2006) had to conclude that these particular images of the physical sciences were dominant among German 16- to 17-year-olds: the girls and boys in their research held the image of physical sciences as
being masculine, difficult and authoritative. Kessels, Rau and Hannover stress the negative impact of this image on young people’s attitudes towards STEM.

**Self-to-prototype matching**

Drawing the attention towards individuals’ perceptions of themselves, Cleaves (2005) emphasises that the image of science and scientists interacts with self-perceptions in young people’s choice of science. Based on investigations of why high-achieving British students choose science during upper secondary, she concludes that the interplay between the self-perception and the image of science and scientists was among the crucial factors. Some students cannot picture themselves as future scientists, and Cleaves argues that this might be part of the reason why many students choose not to study science. Also highlighting identity issues, Hazari, Sonnert, Sadler and Shanahan (2010) discuss what they call the physics identity; how it is developed and how it influences career choice. Drawing on survey data from college and university students in the USA, the physics identity is characterised by factors like the individual’s performance and interests. Having a strong physics identity, they argue, is a good predictor of a physical science career choice. Furthermore, in the article ‘Is science me’, Aschbacher, Li and Roth (2010) identified factors enhancing high school students’ development of science identities. Family support, positive experiences from school science, and extracurricular activities are mentioned in this respect, and Aschbacher and colleagues conclude that science role models and support in multiple communities are among the most important factors in order to develop a science identity.

The relationship between perception of self and perception of STEM practitioners underlies Kessels and colleagues’ work, where educational choices are investigated in light of self-to-prototype matching (Hannover & Kessels, 2002, 2004; Kessels, 2005; Taconis & Kessels, 2009). They propose that choosing science partly depends on the students’ perceptions of themselves and their perceptions of the prototype peer who prefers science. The perceived distance between the prototype and the self, they argue, is a predictor for science choices. For instance, in Taconis and Kessels’ (2009) research, Dutch 9th graders described the prototype peer choosing physics. Compared to the prototype peers choosing economics or language, this peer was described as being less physically and socially attractive, having less social competence and creativity, but being more intelligent and motivated. In describing themselves, the students were more similar to the economics and language prototypes than the science prototype. Drawing on this and similar studies, Kessels and colleagues argue
that these matching processes disfavour a choice of STEM education. Thus, in line with Woelfel and Haller’s description of attitudes, they claim that it is not the prototype alone, but the perceived distance from their self-perception to this prototype that is important regarding educational choices. In order to improve participation in STEM, Kessels and colleagues suggest that significant persons might change the stereotypical beliefs about science practitioners. They conclude that ‘stereotypical beliefs (which constitute prototypes) are changeable via contact with members of the stereotyped group’ (Hannover & Kessels, 2004, p. 65) given that certain conditions are met. Ideally, the youngsters need to meet many group members in order to avoid subtyping (‘this is just an exception’), and the persons need to be clearly defined group members to avoid contrast effects (‘this is not a real physicist’). Hannover and Kessels (2002) claim that the effect depends on the personal meeting. Interaction with a person who is engaged in STEM might potentially reduce the distance between their self-image and how they perceive the STEM prototypes.

**Gender and STEM**

In line with Kessels and colleagues’ self-to-prototype matching, Brickhouse, Lowery and Schultz (2000) investigated 7th grade girls’ science choice focusing on their identity construction and how this overlapped with how the girls perceived the science identity. They conclude, contrary to the idea of a prototypical ‘science girl’, that a variety of girls choose science. In line with this variation, they also relate to science differently. However, despite the fact that different kinds of girls engage in science, the results in Kessels’ (2005) research document that the prototypic physics peers were conceived as more masculine than the prototypic peers favouring music. A masculine image of science might be a barrier to girls’ and women’s engagement in STEM. And indeed, women are underrepresented in many of the STEM fields, like engineering, technology, physics and mathematics (Dobson, 2007; EU, 2006, 2009; National Science Foundation, 2011). Steinke (1997, 1998) claims that the image of science and scientists is indeed one of the major forces causing this. She describes how the masculine image of science is reinforced at home, in school and in the media. According to Steinke, women scientists in the media are normally presented in ways downplaying their expertise and focusing on conflicts related to balancing their professional and personal life. Lack of masculine traits and necessary skills are highlighted. Steinke claims that these images are barriers for girls in becoming interested in science. In line with Kessels and colleagues, she concludes that presenting female scientists that counter stereotypes might be an important step in order to break down these barriers. Exposing
preschool-aged girls to female role models might be more effective than telling teenagers that science is also appropriate for women (Steinke, 1998).

Abilities and attitudes are closely interrelated. Hazari, Tai and Sadler (2007) investigated gender differences in performance and attitudes with respect to affective factors. They propose that affective domains, including encouragement from significant persons, family interests and family attitudes, might strongly influence performance in and attitudes towards science. Drawing on survey data from undergraduate university physics students in the USA, they highlight how girls and boys respond differently to family support. For instance, when family attitudes towards science include ‘science as a way to have a better career’, then boys’ but not girls’ performances are positively influenced. They suggest that this might be related to differences in career preferences, where girls put more emphasis on interpersonal goals than they put on status. Moreover, when fathers encouraged students to participate in science, then girls’ performance increased. This encouragement had no significant effect on boys. Hazari, Tai and Sadler argue that this might be due to the fact that fathers, being members of the more empowered gender in science, have particular influence on girls. Contrary to this, Labudde and colleagues (2000) emphasise the gender similarities. They wanted to develop strategies for physics instruction in order to improve girls’ (and boys’) achievements in and attitudes towards physics. All students, both girls and boys, learned more physics when teachers employed gender sensitive strategies. Moreover, even though the intervention was not designed to identify this, they found that parents hold an important role: parents’ attitudes towards physics were crucial to the youngsters’ attitudes, and parents holding expectations of their children’s performances – both girls and boys – had positive effects (Labudde et al., 2000).

Still, even though Labudde and colleagues make an important point, gender differences with respect to participation in STEM should be addressed here. There are several reasons why females choose STEM educations to a lesser extent than males. Henriksen (2010) points to how research documents gender differences in all factors proposed by Eccles and colleagues’ expectancy-value model for achievement-related choices (Eccles et al., 1983; Eccles & Wigfield, 2002). The documented differences presented by Henriksen disfavour women choosing STEM educations. A variety of efforts might increase women’s expectation of success and valuation of STEM, thus promoting their participation in STEM. Significant persons might contribute strongly in many of these efforts.
Significant persons investigated in science education

A recurring theme in the above review of attitudes, image of science and scientists, and gender issues, is the potential positive influence exerted by significant persons. For instance, 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). Furthermore, Hasse, Sinding and Trentemøller (2008) found that the majority of Danish female physicists in their sample had been inspired to pursue a physics career by their father. Indeed, many science education researchers call for active use of persons to inspire and motivate young people to engage in STEM. Frost, Reiss and Frost (2005) claim that important, historical female scientists are overlooked in UK school science curricula. They suggest using role models in order to prevent members of underachieving groups from internalising negative views about themselves. Moreover, in their report on declining enrolments in high school science in Australia, Lyons and Quinn (2010) hold up role models as crucial for participation in STEM. ‘I can’t picture myself as a scientist’ was the most frequent reason year 11 students gave for not choosing science. In order to picture oneself as a scientist, Article I in this thesis points to the important role parents and teachers might play, and indeed, parents and teachers are the most frequently studied significant persons in science education research.

Parents’ influence on achievements, attitudes and participation

Smith and Hausafus (1998) identify which aspects of family support influence achievements in mathematics and science. Drawing on the test scores of minority 8th grade students and interviews with their parents, Smith and Hausafus conclude that ‘parental involvement, parenting style, and parental expectations all affect a child’s education’ (ibid., p. 123). Students score higher on science and mathematics tests if their parents have made them see the importance of mathematics and science courses for education and careers, and if they have involved them in extracurricular STEM activities. Smith and Hausafus encourage parents to get involved in their youngsters’ education and to inspire STEM activities, because ‘these role models may help early adolescents to see themselves as practicing scientists or mathematicians in their new adult identity’ (ibid., p. 123). Dryler (1998) also discusses significant person influence, pointing to both positive and negative outcomes. On one hand, a father employed in an engineering company might influence his children to pursue the same career through sharing knowledge and providing information about a
specific sector. On the other hand, a STEM employed father might be seen as confirming traditional gender roles, leading a daughter to pursue a traditional female career. That is; it is not given whether the influence will be specific (‘pursue this particular career’) or general (‘get a job according to traditional gender roles’). However, drawing on a sample of 73 000 Swedish teenagers, Dryler suggests that the former effect is the strongest: a daughter is much more likely to make the unusual choice of a technical career if her father has such an education or career.

Adamuti-Trache and Andres (2008) examined parents’ influence on STEM educational choices drawing on longitudinal data of Canadian students from upper secondary throughout post-secondary studies. ‘Parental education plays a determinant role in senior high school course choices made by respondents’, they argue, ‘in that there is a noticeable correspondence between students with university-educated parents and the completion of science courses in high school’ (ibid., pp. 1575-1576). Moreover, young persons with university educated parents are more likely to attend university directly after high school. Adamuti-Trache and Andres discuss how parents’ understanding of STEM and the importance of STEM in the workforce influence how they consider their youngsters’ need for these subjects in their education. Drawing on similar reflections, it is suggested in Article I in this thesis that parents might be a target group of STEM recruitment efforts. Inviting them to STEM courses to enable them to support children’s homework, and informing them about the career opportunities opened up by STEM, might potentially encourage them to promote STEM participation at home.

Teachers’ influence on achievements, attitudes and participation
Teachers are assumed to be key persons in developing girls and boys’ abilities and attitudes. Exemplifying this, ‘when students, parents, principals and teachers were asked about what influences students’ achievements, all but the teachers emphasized the relationships between the teachers and the students’ (Hattie, 2009, p. 118). Among the 138 factors for which Hattie summarises review articles, the student-teacher relationship was ranked as the 11th most important factor for learning. Furthermore, Cornelius-White (2007) reviewed over 1000 articles – targeting a total of 355 325 students and 14 851 teachers – in order to investigate the student-teacher relationship. Three of these articles will be mentioned here: Rogers (1969) highlights the importance of trust in learners and the creation of a learning environment that is acceptant and empathic. McCombs (2004) claims that learning is
enhanced if the students have supportive relationships. Finally, Poplin and Weeres (1994)
show how negative teacher-student relationships are the most frequently mentioned reason
for problems in school. When positive aspects of school are brought up, positive
relationships are usually mentioned: relationships with a teacher who cares, listens,
understands, who is honest, open and sensitive. Cornelius-White shows through his review
that learning strategies focusing on the student-teacher relationship correlate above average
with positive outcomes in terms of cognitive, affective and behavioural effects. Positive
relationships like these are elaborated on in Article II in this thesis, where the participants in
the Norwegian mentoring project ENT3R share their positive experiences of the project.
They hold up the positive atmosphere created by the mentors as a major reason for taking
part in the project. Furthermore, the participants describe how they are encouraged to
participate in science and mathematics through experiences and insight gained in
interpersonal relationships with their mentors.

Many researchers have focused on the ‘like is good for like’ principle. Female teachers are
assumed to be better for girls, and male teachers are assumed to be better for boys, with
respect to both their achievements and their attitudes towards STEM. These assumptions
generally receive little empirical support (e.g., Carrington, Tymms, & Merrell, 2008).
Gilmartin, Denson, Li, Bryant and Aschbacher (2007) discuss whether female science
teachers are viewed as representing scientists or just representing teachers. If students
separate scientists from science teachers, this ‘assures that they will have few, if any,
matched science role models in high school’ and they are ‘robbed of the opportunity to have
role models or examples of “possible scientific selves” in formative stages of their academic
experiences’ (ibid., p. 1001). With respect to male teachers, Bricheno and Thornton (2007)
conclude that it is not viable to promote male teachers as role models for underachieving
boys. In their research, only about 2% of the 10- to 16-year-old boys referred to their
teacher as their role model. This might, however, partly be due to how role models were
defined to the participants, including that role models are someone you ‘want to be like’.
This is not something an early teenager is very likely to say about a teacher.

*Employing significant persons in efforts to inspire STEM participation*

The above paragraphs indicate that significant persons play important roles in young
people’s educational choices. Drawing on such findings, many projects have been initiated
in order to improve achievements, attitudes and participation in STEM. These projects
provide valuable insight into how significant persons affect young people. For instance, Bruce, Bruce, Conrad and Huang (1997) report from the SEARCH project in the USA, where university science students throughout a semester participated both as curriculum planners and as teachers for at least two hours a week at a local school. Bruce and colleagues report a strong role modelling effect in this project. The science students ‘had substantially affected children’s images of scientists’ (ibid., p. 17). Their presence in the classrooms gave the children a chance to interact with science students, potentially countering the stereotypes about scientists previously held by the children. The girls and boys got to see different persons engaged in science, and ‘many had reinforced the idea that they could be scientists, too’ (ibid., p. 20).

Similarly, Buck, Clark, Leslie-Pelecky, Lu and Cerda-Lizarraga (2008) describe how a group of 8th grade girls in the USA came to see themselves as possible future scientists through an intervention. The researchers wanted to investigate both the cognitive processes in girls identifying a person as a role model in science and the cognitive processes in female scientists seeking to be perceived as role models. In this intervention, female STEM graduate students participated in classroom activities and initiated projects in class at least two hours a week throughout the year. Focus groups were conducted with both the 8th grade girls and the female STEM students prior to the intervention, after three months and after six months. Initially, the female scientists focused on the importance of academic success in order to be a role model. By the third focus group, the personal relationships with the students were in focus. They highlighted the importance of role models being encouraging, easy to talk to, and being able to connect with the students. This description resembles how the girls in the 8th grade had described role models six months earlier – as someone you feel a strong connection to. Scientists, they argued at the beginning of the intervention, could not achieve this, being genius people without social skills. Three months later, a great shift in their image of scientists had occurred. Scientists might very well be women; they might be kind, responsible, humorous and nice to talk to. The girls concluded that ‘scientists are normal people, but know science’ (ibid., p. 698). After an additional three months, the interactions with the scientists in terms of conversations, smiles and gestures led them to realise how they themselves could be scientists. Buck and colleagues conclude: ‘It was only after they came to have a relationship with scientists, ones in which they talked about families and fashion in addition to science and professions (i.e., a personal relationship), that they came to understand that a woman scientist could be not only a role model, but a role
model to them’ (ibid., p. 704). Thus, the girls learned something about themselves through personal relationships with role models.

Following these appraisals of significant persons and their influence, it is appropriate to make a critical remark. Zirkel (2002) raises the important question about causality: do role models create STEM aspirations or do those with STEM aspirations seek to identify with role models? It might be that many participants in such projects are already committed to STEM educations and that the projects provide them with someone to identify with. However, Zirkel argues that ‘the evidence taken as a whole is more supportive of the position that the role models came first’ (ibid., p. 372).
2.4. Summary of theory and science education research

The enrolment patterns in STEM educations and careers might partly be understood by drawing on sociological perspectives of youth in Western countries. Young people are free to choose any education they want, pursuing the values that are important to them. The challenge is to make an educational choice that is compatible with the identity they are constructing. An overwhelming number of possible choices often leads them to choose the familiar education, literally speaking. Social psychology provides insight into the youngsters’ selves and their attitude development. According to structural symbolic interactionism, they are constantly developing, yet constrained by and always in reciprocal interaction with other persons. Woelfel and Haller (1971) suggest four ways that significant persons might influence adolescents’ attitudes, which are contingent on their self-view and their perception of the attitude objects. Using Eccles and colleagues’ (1983) expectancy-value model, examples were given here of how these significant persons might influence attitudes towards and choice of educations within STEM.

Science education literature suggests that adolescents’ relationships to STEM are dependent upon their image of science, scientists and themselves. Research suggests a general mismatch between the two – how young people in Western countries view themselves and how they view STEM. In particular, girls face many socio-cultural barriers keeping them from choosing STEM. On this basis, many researchers have looked for ways to use significant persons in order to create interest in STEM. Parents and teachers are frequently mentioned in this respect. Many projects have been initiated in order to provide young people with science role models. Two such projects were presented here, exemplifying the importance of interpersonal relationships with STEM practitioners in order for adolescents to see themselves as scientists.
3. METHODS
3.1. Research methods used in this thesis

In investigating a phenomenon, it is helpful to use different research methods in order to gain a deep understanding. Several methods are used for data collection and analysis in the three articles included in this thesis, providing different perspectives and complementing knowledge concerning significant person influence. In this section, the different methods will be discussed.

Article I draws on questionnaire data collected in the Lily project. Questionnaire responses to both closed and open-ended questions concerning tertiary educational choice are analysed. Classical statistics are used in analysing the closed questions, while the open-ended questions are analysed using predetermined codes.

Focus group interviews are the basis for Article II, where participants in a mathematics mentoring project share their experiences of the project. This data material is coded both according to predetermined codes and using an open coding strategy.

Rasch analysis is used on questionnaire data in Article III. This method will receive special attention in this methods section due to the lead role it plays in the article and the fact that the method might be unknown to many science education researchers.
3.2. Questionnaire data from the Lily project

The first article in this thesis draws on questionnaire data collected in the Lily project (Schreiner et al., 2010). This project was initiated in 2008 by the Norwegian Centre for Science Education and the Department of Physics at the University of Oslo with financial and practical support from several public and private collaboration partners. The main objective was to produce knowledge applicable for stakeholders seeking to increase participation in STEM, with a particular focus on educations and branches with low participation and skewed gender balance. In the Norwegian context, subjects like physics, mathematics, engineering and technology are of particular interest in this respect. In addition to the questionnaire described in this section, the researchers in project Lily developed questionnaires targeted at tertiary students in non-STEM disciplines (ibid.) and students in upper secondary school (Bøe, 2012). The project is a forerunner to the IRIS project, which is an EU project with partners in Norway, Denmark, the UK, Slovenia and Italy (IRIS Consortium, 2012). All in all, project Lily has resulted in a number of seminars, conference papers, public press articles, reports, master theses, PhDs and journal articles – including an article in this thesis.

In order to achieve the overall objective, the Lily project investigated young people’s values, experiences and priorities related to educational choices. The researchers in project Lily needed to efficiently collect large amounts of data to describe major patterns in Norwegian youths’ educational choices, and thus a questionnaire research design was chosen. The pen-and-paper questionnaire was developed during the spring of 2008 with all Norwegian students beginning a three- or five-year tertiary STEM education in the fall of 2008 as the main target group. The researchers drew on experiences from foregoing projects, like the ROSE project (Sjøberg & Schreiner, 2010) and the FUN project (Angell, Guttersrud, Henriksen, & Isnes, 2004), theoretical considerations, like sociological theories about youth and Eccles and colleagues’ expectancy-value model for achievement-related choices (Eccles et al., 1983), and science education literature. The ROSE questionnaire format and selected items from this was the starting point. Pilot versions of the questionnaire were discussed with fellow researchers and persons responsible for student recruitment in higher education institutions. In the final stage of the questionnaire development, two focus groups were conducted with students in the target group who had completed the questionnaire. They discussed general impressions, interpretations of items,
length, and format, and these discussions resulted in minor adjustments. The final questionnaire is given in Appendix 1.

Selected persons employed in student administration in all public Norwegian universities and university colleges were contacted by the Lily project group to be local project representatives. Out of 26 eligible higher education institutions offering STEM educations, 25 accepted the invitation to participate in the study. The questionnaire data was collected in August and September 2008 during the first weeks of the first semester of their respective educations. It was administered by the institutions’ project representatives during an obligatory lecture or event and took about 20 minutes to complete. The questionnaires were then sent to the University of Oslo, where 18 research assistants coded the responses into Excel files. The closed questions were coded by assigning numbers to the response categories, and the open questions were transcribed verbatim. Members from the research group transferred data from Excel files into SPSS 16.0 (SPSS, 2007) to conduct analyses. With regard to anonymity and other research guidelines, for instance concerning filing of questionnaires, handling computer files and publication of results, the Lily project received official permissions from the Norwegian Social Science Data Services.

Article I refers to five closed questions (Questions 14 a-e), two open-ended questions (Questions 16 and 20) and one combined question (Question 19 k). The closed questions are analysed simply by drawing on mean scores and the proportion of students who respond in the different response categories. Thus, analysis of the closed questions utilised in Article I will not be treated in-depth here. The forthcoming validity discussion concerning the Lily questionnaire will, however, also be relevant for the validity of inferences drawn from the closed questions. Following this, analyses of the open-ended questions will be specifically presented.

Validity in this questionnaire study

In general, validity is not a quality of a test, but a quality of the inferences drawn from data material (Shadish, Cook, & Campbell, 2002). It takes the form of an argument drawing on convergent evidence for the specific inferences. Historically, three types of validity have been proposed: (1) content validity, focusing on expert judgements about the relevance of the test, (2) criterion-based validity, focusing on empirical correlations with external criterions, and (3) construct validity, investigating whether or not the test measures what it
claims to measure. Among others, Messick (1989) presents a unified version of construct validity as he claims that ‘all validation is construct validation, in the sense that all validity evidence contributes to (or undercuts) the empirical grounding or trustworthiness of the score interpretation’ (p. 8). Establishing validity might thus include several kinds of evidence depending on the inferences drawn from the data material, for instance factor analyses, correlation coefficients, content analyses, multi-method studies and reliability estimates. Messick categorises seven common ways of configuring validity evidence, namely by examining the relevance and representativeness of the test, the internal structure, the external structure, the processes underlying item response, the generalisability, the occurrence of appropriate variations, and the value implications and social consequences.

These seven ways taken together would constitute an exemplary validity argument. This is, however, not always possible or appropriate. Concerning the inferences drawn from project Lily, three factors will be discussed here that constitute a general validity argument; reliability, construct validity and generalisability. This general argument underlies the arguments related to the specific inferences drawn from the questionnaire data.

**Reliability**

Reliability concerns ‘the amount of measurement error associated with the scores’ (Frisbie, 1988, p. 25). It is a property of the test scores and not the test itself, in that it concerns the consistency of the test scores. Would the results of project Lily be similar if the questionnaire was administered to an equivalent group in an equivalent setting? According to Traub and Rowley (1991), threats against reliability might be found in the test itself (e.g., test length, item quality), in the conditions of administration (e.g., instructions, time limits, physical conditions) and in the target group (e.g., maturity, homogeneity). Moreover, errors in the test scores might be a result of faulty scoring procedures (Brown, 1996). In different ways, the Lily project counters many potential threats against reliability. Several items and the questionnaire format had been tested through the ROSE study. No time limit was defined by the Lily researchers. The persons administering the questionnaire were instructed in how the data should be collected, and the physical conditions were most probably good, as most information meetings are held in university classrooms.

In project Lily, about 200 questionnaires were coded twice by separate research assistants. On average, 0.8 coding errors were found per questionnaire containing 176 questions. That
is; the coding precision is about 99.5%, which is acceptable. Finally, the computer file was cleaned by members of the research group. Missing values on items typically ranged from 2% to 3%.

The reliability of the Lily data is strengthened through comparisons with results from similar research projects, like the ROSE and the IRIS studies (preliminary results). Conclusively, the reliability in project Lily is considered acceptable. This is, however, not sufficient to prove the quality of test scores. The test might still ‘measure abilities that are not considered important, and the test scores may be interpreted incorrectly or used for inappropriate purposes’ (Traub & Rowley, 1991, p. 41). These and related topics will be treated in the following paragraphs.

**Construct validity**

Even in a straightforward questionnaire, interpretations take place. All persons, including respondents, researchers, and readers of research articles, have their own understanding of the questions being asked and the response scale being used. Items are phrased as specific questions, yet they are often interpreted in general terms. Construct validity regards ‘inferences about the higher order constructs that represent sampling particulars’ (Shadish et al., 2002, p. 38). To investigate construct validity, the questionnaire development in project Lily included focus groups with members of the target group who had completed the questionnaire. This provided the researchers with deeper insight into some respondents’ interpretations of different items. Moreover, construct validity is strengthened whenever theoretically suggested clustering of items covary sufficiently (Gable & Wolf, 1993). Exploratory factor analyses of data material from the main study returned factors similar to those suggested by theory. Most of these had Cronbach’s alpha about 0.7 or higher (Schreiner et al., 2010). Details of these analyses will not be provided here, since only single items from the questionnaire are utilised in this thesis.

Also affecting construct validity is interpretations of the response scale. The Lily researchers chose to use a four-point Likert scale. Increasing the number of response categories from four to five would provide a mid-category with the opportunity for neutral responses. The decision was made to avoid this. A mid-category is sometimes used not only to express neutrality, but also to express indecision and indifference (Gable & Wolf, 1993), like ‘I don’t know’ or ‘Does not apply’ responses (Kulas, Stachowski, & Haynes, 2008).
These respondents should not be grouped with those who have a well-considered neutral opinion.

Although Rasch analysis, which will be presented later in this chapter, was not conducted on the Lily data material, note that this analysis is committed to issues of construct validity. Specifically, Rasch analysis supports the development of invariant measures that capture unidimensional constructs.

**Generalisability**
The target group in project Lily include the entire Norwegian 2008 cohort of tertiary STEM freshmen. About 70% of these responded to the Lily questionnaire. There is, however, reason to believe that the inferences drawn from project Lily can be generalised to the entire target group. Most students not represented in the data material were never offered the opportunity to participate, due to practical or administrative reasons. Feedback from the contact persons indicates that practically speaking all students present at the obligatory meeting chose to complete the questionnaire. Moreover, the gender distribution is similar in the data material as in the entire target group. Thus, it is assumed here that the inferences drawn from the Lily questionnaire generalise to the entire 2008 cohort of tertiary STEM freshmen in Norway.

A different issue is whether the results from project Lily can be generalised to STEM students in other cohorts or in other countries. The global financial crisis emerged at about the same time as the Lily respondents completed their questionnaires. It is not unlikely that the 2009 cohort would respond differently to items concerning job security. Moreover, even though many trends in the youth culture are similar in Norway as in other Western countries, national and cultural differences might influence responses to specific items (Singh, 1995). This should be kept in mind when discussing the validity of certain inferences, for instance with regard to the item concerning inspiration from publicly known persons in the media (Appendix 1, Question 19 k). The number of national STEM celebrities might vary greatly between countries.

**Analysis of open-ended questions**

Article I refers to two open-ended questions included in the Lily questionnaire, namely Question 16 and Question 20 (Appendix 1): ‘Please write about your choice of study’ and
'Can you name one or more experiences or activities from your background that have influenced your current choice of education?' The questions were followed by examples of typical experiences to inspire the respondents’ thinking processes. In analysing the responses to the open-ended questions, two different approaches were used: a quasi-statistical method where the occurrences of different significant persons in the responses were counted, and coding according to predetermined codes provided by Woelfel and Haller’s framework.

**Counting the occurrences of significant persons**

Responses to open-ended questions are qualitative data and should be treated accordingly. There is, however, good reason to apply a quasi-statistical approach to assess the amount of evidence for different claims (Maxwell, 1996). Qualitative researchers, commonly using relative terms like ‘often’, ‘some’ and ‘most’, might benefit from providing counts, leaving the choice of descriptive terms to the reader (Onwuegbuzie & Daniel, 2003). Thus, all persons mentioned in the open-ended questions were counted. The data material was read three times in this respect. The different codes, like ‘parents’, ‘father’, ‘relative’, ‘uncle’, ‘friend’, ‘teacher’, ‘celebrities’ and ‘person’, were developed through the first read-through. The responses were then read and coded on two separate occasions by the author. Ideally, this coding would be conducted by two different researchers. Unfortunately, no colleague had the opportunity to take part in this process.

The two rounds of coding provided identical results, strengthening the reliability argument. Concerning the validity of these results, however, different factors should be kept in mind. Firstly, many groups of persons are contained in other groups, for example, ‘father’ is contained in ‘parents’, which in turn is contained in ‘family’. Thus, when reporting on the number of respondents attributing fathers with inspiration for the educational choice, the reported number is probably too low. Many students might have thought about their fathers when writing about ‘parents’, ‘family’ or ‘someone I know’, but these instances have to be disregarded from the ‘father’ category as they might very well concern someone else. Secondly, many responses only contain the mention of a person with no further explanation. Thus, the significant person might actually have exerted a negative influence, as in the case of the respondent who did not want to become like ‘certain other persons in my family’. Obvious negative influences like these were coded separately. In the main counting,
however, the persons mentioned with only a word are assumed to have exerted a positive influence and are included.

Coding according to Woelfel and Haller’s framework

Responses to open-ended questions in Lily were also analysed using predetermined codes, where ‘key codes are determined either on an a priori basis (e.g. derived from theory or research questions) or from an initial read of the data’ (Robson, 2002, p. 458). A main objective in Article I was to draw on the open-ended questions to thoroughly describe how teachers and parents influenced the Lily respondents with regard to the choice of a STEM education. The framework of Woelfel and Haller (1971) provided four predetermined categories to structure this description. Thus, these four categories served as templates for data analysis, where the data was split into discrete parts:

The size of the part chosen is whatever seems to be a unit in the data: perhaps a sentence, or an utterance, or a paragraph. The question asked is: ‘What is this piece of data an example of?’ (Robson, 2002, p. 493)

Using NVIVO 8 software (QSR International Pty Ltd., 2008), this coding resulted in four collections of responses, one collection for each of the four categories suggested by Woelfel and Haller. Then, the responses in each category were read over and over in order to capture the essence of these. Subcategories emerged naturally in this process, structuring the researcher’s interpretation. Finally, the responses were described as found in Article I.

Obviously, these descriptions are subject to self-report bias, as for most inferences drawn from questionnaire data. Maturity, self-knowledge and honesty play important roles when adolescents identify and describe persons who influence them. For instance, in Section 5.5 in this thesis, it is discussed how the self-report bias might apply to responses concerning STEM celebrities. Moreover, the validity of such descriptions relies heavily on two steps in the process: Did the researcher interpret the responses well? And was the researcher able to describe these interpretations? Ary, Jacobs and Sorensen address these questions in writing about credibility: ‘The researcher has an obligation to represent the realities of the research participants as accurately as possible and must provide assurances in the report that this obligation was met’ (2010, p. 498). This obligation was to some degree met by including a variety of quotes in the descriptions, giving the readers access to actual examples of the researcher’s interpretations. Moreover, the results have been thoroughly discussed with
colleagues. They share the researcher’s interpretation of the data material and find that the descriptions make sense in light of related results from project Lily and similar studies.

Finally, also threatening the validity of these results are the questions supplementing the open-ended questions. For instance, the question ‘Please write about your choice of study’ was supplemented with ‘Was it hard to choose? Somewhat random? “Always known” that this was what you wanted? A particular incident determined the choice?’ Responses quoting these verbatim, like the many ‘Somewhat random’ responses, indicate that the supplementing cues influenced the students. Despite this threat, the Lily researchers found the supplementing questions worthwhile to include. Experiences from the FUN study (Angell et al., 2004) indicated that supplementing cues might be helpful in stimulating respondents to thoroughly describe their experiences leading up to educational choice.
3.3. Focus group interviews

Rationale for using focus groups in investigating ENT3R

The mentoring project ENT3R was investigated through focus group interviews with participants in the project. ENT3R is an effort to increase participation in STEM. In this project, 15- to 19-year-olds come to their local tertiary educational institution for weekly ‘maths trainings’, where they meet STEM students for mathematics related activities. The results from this investigation are presented in the second article in this thesis. The main questions in the ENT3R article regard what the participants appreciate about the project and in what ways their experiences might heighten the probability of a STEM educational choice. Thus, as many as possible of the participants’ different experiences had to be brought out. According to Suyono, Piet, Stirling and Ross, results from focus groups ‘are qualitative in that they indicate the breadth of attitudes that exist on a topic rather than quantifying them’ (1981, p. 434). In order to answer the research questions, this ‘breadth’ was essential, suggesting focus groups as a method for data collection. Moreover, the importance of having the participants themselves share experiences from ENT3R, and not the mentors, was decisive: ‘The qualitative researcher is interested in perspectives rather than truth’ (Merriam, 1988, p. 168). That is; the participants’ attitudes towards STEM are influenced by how they perceive the persons and the activities in ENT3R, and not by how the mentors actually are or by what actually happens at the maths trainings. According to structural symbolic interactionism (Stryker, 1980), people construct their perceptions in interaction with other persons. The fellow participants in ENT3R are persons with whom their perceptions of STEM and their perceptions of themselves with regard to STEM are partly developed. Thus, having them sit together to discuss ENT3R might in some way resemble how their perceptions are formed in a daily, interactive context.

Focus group interviews have several properties suitable for the ENT3R research: this is an efficient and inexpensive way of collecting data. The design is flexible and discussions might develop in unplanned and potentially important directions, allowing the researchers to change the interview guide in-between the focus groups according to topics that might have emerged. Moreover, group dynamic plays an important role. The participants might stimulate each other, help in recollecting situations, and trigger associated memories. They might balance and confirm each other’s views, providing the researchers with a more
nuanced impression of the issue at hand. Unexpected views and experiences might be brought out that would not be included in a questionnaire developed by the researchers. Moreover, focus groups might be ‘raising consciousness and empowering participants’ (Johnson, 1996, p. 517). That is; by sharing and reflecting upon their expectations and positive experiences, the participants might become more conscious about the benefits of the project and their expectations are more likely to be fulfilled. Stating mastery or achievement goals has been shown to positively influence goal attainment (Harackiewicz, Barron, & Elliot, 1998). For all these reasons, focus groups with ENT3R participants were considered as suitable for the purposes of this research.

**Preparation and data collection**

Inviting young persons to discuss personal experiences and relationships in focus groups requires precaution and ethical considerations. The participants need to know what they have been invited to, they need to know their formal rights, and they need to feel comfortable and well taken care of. Legal rules and suggested guidelines stated by the Norwegian Social Science Data Services, who formally approved the research, were strictly followed. Morgan and Krueger’s (1998) *Focus Group Kit*, consisting of six volumes on issues like planning, developing questions, moderating and analysing focus groups, was a primary source on focus groups and the basis for the considerations described here.

Having decided upon the research focus, a meeting was held with two leaders and two mentors of ENT3R. This gave the researchers the opportunity to properly explain the aims of the research and to get necessary permissions. The leaders and the mentors shared useful suggestions and relevant insight about the mentors, participants, activities and the project in general. After this meeting, the development of the interview guide began. Eccles and colleagues’ expectancy-value model for achievement-related choices (Eccles et al., 1983) was used as a starting point. This framework would ensure the inclusion of a variety of relevant questions regarding experiences in ENT3R. The specific questions were phrased in collaboration with colleagues, drawing on findings in project Lily and suggestions from mentors in ENT3R. The final interview guide contained two introductory questions, three main questions, five collections of support questions for each of the five components in Eccles and colleagues’ model, and three concluding questions. The support questions were used as suggestions for follow-up questions whenever a participant brought up a certain
topic. The concluding questions would provide the participants with a final chance to share whatever they had in mind. Moreover, their thoughts about ENT3R were likely to be well reasoned at this point, having discussed the project for almost an hour. A translated version of the interview guide is given in Appendix 2.

To answer the research questions it was important to recruit participants assumed to have many positive experiences of ENT3R. Thus, four mentor groups in ENT3R at the University of Oslo were randomly chosen, and all students were invited who had participated in the project for at least one semester. This was the only selection criterion. Certainly, it would be interesting to talk to those who participated for only one or a few maths trainings and then decided to quit. Learning about their experiences and reasons for opting out would provide valuable insight into the project. However, due to the specific research questions and practical considerations, they were not included in this particular research design. They are, however, suggested as suitable informants in a potential follow-up study.

The groups were homogeneous in that all participants were assumed to have positive attitudes towards the project. Homogeneity with regard to gender was considered, but the gender focus in this particular article was minimal. Moreover, the first focus groups indicated that typical benefits of having single-gender groups, like good communication flow and the feeling of a safe environment, were already present. The mood was light and the participants seemed confident.

The participants were invited to participate by their mentors at a maths training two weeks prior to the focus groups. The following week, the mentors handed out information letters about the research and the focus groups, one exemplar to the participants (Appendix 3) and a different exemplar to their parents (Appendix 4). For the 15-year-old participants, a parent or caretaker had to sign a permission letter in order for the girl or boy to take part in the focus group. All in all, 25 participants took part in four focus groups. The gender and age distribution in the focus groups were fairly representative of the total population of ENT3R participants, with 11 girls and 15 boys taking part, most of them from 15 to 17 years old, but some 18- and 19-year-olds as well.

Prior to the focus groups, the two authors of Article II (the undersigned included) were present during the participants’ maths trainings to make observations. This deepened their understanding of the project in general and of these participants’ experiences in particular.
The focus groups were held immediately after the maths trainings, starting with 30 minutes of pizza and small-talk to make everyone feel relaxed and confident to talk. This was followed by the actual focus group interview, which typically lasted for about 45 minutes. The focus groups were arranged immediately after the maths trainings for two purposes. Firstly, this was assumed to be convenient for the participants, and secondly, their memories from the project were assumed to be more easily accessible. The two authors were moderators in all four focus groups. This was a great advantage with respect to discussions in-between the focus groups, where impressions and interpretations were shared. Audio recorders were used during the focus groups in addition to personal notes concerning non-verbal communication, impressions and ideas for topics to discuss. The audio recordings were transcribed by the authors, providing them with a second experience with the data material. The transcriptions were coded in NVIVO (2008) in two different ways according to the two research questions.

Notably, three additional focus groups were conducted with ENT3R participants to support the development of the questionnaire instrument presented in Article III. This interview guide, given in Appendix 5, focuses merely on the mentors. It was developed based on insight gained through the four prior focus groups and Woelfel and Haller’s (1971) framework. In total, 12 girls and 5 boys took part in these three additional discussions, and phrases and words that occurred frequently in these focus group discussions were used to generate ideas for questionnaire items in Article III.

**Open coding of focus group transcriptions**

The first research question was ‘What do the participants in ENT3R appreciate about the project?’ To identify and put emphasis on important features of the experiences they shared, the data material was approached through an open coding process. Even though this approach is commonly used in grounded theory research (Corbin & Strauss, 1990), this study is not regarded as such. In grounded theory, categories are supposed to ‘be integrated into a single one at a higher degree of abstraction. This must remain grounded in the data but is abstract and integrated as well as being highly condensed’ (Robson, 2002, p. 495). A grounded theory approach ideally includes axial and selective coding in addition to open coding. The ENT3R data was coded merely to provide a thorough description of the main themes in respondents’ descriptions of their experiences, not to develop theory.
In open coding, the codes are supposed to appear ‘naturally’ from the data material. Thus, open coding ‘is essentially interpreting rather than summarizing’ (Robson, 2002, p. 494), where different possibilities in the data are teased out. The initial codes that appear after the first reading of the data might be modified and changed throughout the analysis process. The process is ‘encouraged by stepping back from the data from time to time and getting an overall feel for what is going on’ (ibid., p. 494), and in the ENT3R research this process lasted for ten months. The two authors worked with the data material separately, but met several times to discuss interpretations, ideas and main impressions. Working with the data over time, developing interpretations and coding structures, provided ideas about the core categories. Through discussions and separate work in-between the meetings, the authors slowly converged towards a common and in-depth understanding of ‘what is going on’ in ENT3R. The main categories and final codes were decided upon, and the data material was coded once more according to these. The quotes collected through this coding process serve as ‘empirical evidence for template categories’ (ibid., p. 458).

**Coding according to Eccles and colleagues’ model**

The second research question concerned in what ways the experiences participants shared in the focus groups might have increased their motivation for a STEM education and career. This was answered by identifying quotes that exemplified components in Eccles and colleagues’ expectancy-value model for achievement-related choices (Eccles et al., 1983). Such a coding process is similar to the process described in the Lily methods section, with main codes provided by Eccles and colleagues’ model instead of Woelfel and Haller’s framework. For instance, the quote ‘you learn and get to know how science can be applied’ was coded as ‘utility value’ and the quote ‘you dare to meet challenges you normally wouldn’t have thought you could do’ was coded as ‘expectation of success’.

**Validity in this focus group study**

Looking at the challenges faced by researchers conducting focus groups, it is evident that the authors’ limited experience with this method was a great challenge with regard to the ENT3R research. Conducting focus groups takes experience and expertise, and the two authors had only conducted a handful of focus groups prior to this research. It is unknown whether or not the participants have been stimulated to share all relevant experiences. Important key words might have been ignored and trivialities might have been over-
emphasised. Moreover, ‘the live and immediate nature of the interaction’ (Robson, 2002, p. 285) might have led the authors to get carried away in enthusiasm. For instance, if the authors committed themselves to a first impression of the mentors as ‘fantastic’, then the analysis process and the final presentation of the mentors would lack objectivity and nuances.

Being aware of such pitfalls, different steps were taken in order to compensate for the lack of experience. Firstly, the authors collaborated closely throughout the process with colleagues who had focus group experience. These colleagues supported the development of the interview guide, they shared suggestions for practical arrangements, and they were important discussion partners throughout the entire process. Secondly, meeting the two leaders and the two mentors of ENT3R provided insight into the main intentions of the project in general and the mentors’ viewpoints in particular. Listening to how the mentors described their thoughts about being mentors and their relationships to the participants was a valuable addition to the participants’ descriptions of their relationships to the mentors. Thirdly, to gain first-hand knowledge about the maths trainings, the authors observed the participants’ maths trainings prior to the focus groups. This made it easier to understand the contexts of the experiences shared in the focus groups. By taking all these steps, in addition to conducting the focus groups, the authors gained insight into the project not only through the participants’ viewpoints, but also through the leaders’, mentors’ and their own viewpoints. This triangulation provided a thorough insight into ENT3R. Furthermore, the authors’ interpretations of the focus groups are to some extent validated by the same persons: at the end of the focus groups, the authors summarised the discussion and shared their main impressions for the participants to comment on, reject or confirm. In the final stage of the analysis process, the results were presented to all leaders and mentors in ENT3R at the University of Oslo. They responded that the results made sense in light of their experience. Thus, the validity of the ENT3R research is strengthened by the fact that the participants, the mentors and the leaders have all provided insight into the project, and that the authors’ results and conclusions in some way are confirmed by all the same persons.

Finally, the following issue will be addressed: ‘Focus groups explore collective phenomena, not individual ones. Attempts to infer the latter from focus group data are likely to be unfounded’ (Robson, 2002, p. 289). This statement raises two important questions: Is attitude change a collective phenomenon? And if not; are the conclusions about the ENT3R
mentors’ influence unfounded? The answer to the first question is both yes and no. An attitude, being affectively, behaviourally or cognitively defined, is a highly individual concept, and the result of attitude change lies within the individual. On the other hand, drawing on symbolic interactionism, the process of attitude change takes place in interaction with other persons. This might happen in several ways and encompasses processes described in Bandura’s (1977) social learning theory and the different phenomena described as social influence (Cialdini & Goldstein, 2004). Still, any conclusions from these focus groups must be carefully drawn. In Article II, conclusions regarding mentors’ influence on participation in STEM are phrased in probabilistic terms; the girls and boys share stories in the focus groups exemplifying experiences hypothesised to heighten the probability of attitude change. Thus, answering the second question, the conclusions in the ENT3R article are not unfounded. They merely draw on the shared experiences in order to suggest ways for mentors to exert positive influence with regard to attitudes towards and choice of educations within STEM.
3.4. Rasch analysis

Rasch analysis is applied in Article III and will be presented here. This method will receive special attention for two reasons. Firstly, Article III presents the development of a psychometric instrument. Thus, the method is of great importance. Secondly, although many science education journals publish articles using Rasch analysis (e.g., *Science Education* and *International Journal of Science Education*), this method is not widely applied by science education researchers. Many researchers might benefit from using this method in their research. The following presentation will therefore be aimed at those who have no previous knowledge about Rasch analysis, and it will cover the properties used in Article III.

In this introduction, the terms ‘correct/incorrect’ will be used to describe responses, and ability and difficulty will be used to describe persons and items, respectively. These terms might seem strange when it comes to attitude measurement, but they do not imply that psychological measurement is synonymous with ability measurement. Obviously, items measuring attitudes are not difficult per se – everyone is able to respond in the top category providing a ‘top score’. In attitude measurement, however, *item difficulty* refers to how common it is to endorse the statement to different degrees. Similarly, *person ability* refers to the easiness for someone to endorse statements concerning the attitude being investigated. That is; considering a random group of Norwegian teenagers, many would endorse a statement like ‘Science has been important to the development of our society’, which would exemplify an ‘easy’ item with low item difficulty. This statement might be endorsed by most respondents, including those with ‘low person ability’, which in this case refers to those who have negative attitudes towards science. Furthermore, only persons with ‘high person ability’, who in this case have very positive attitudes towards science, would endorse a statement like ‘I definitely want to pursue a career within science’. This exemplifies an item with high difficulty. In the following, where the dichotomous case for the Rasch model is presented, ‘correct’ and ‘incorrect’ are used to describe endorsement and non-endorsement of an item, respectively. Conclusively, the terms ability, difficulty, correct and incorrect will be used in this introduction, both for the sake of notational convenience and to make readers familiar with the notation commonly used in Rasch theory literature.
Background of Rasch analysis

*Measurement* might be defined as ‘the assignment of numerals to objects or events according to rules’ (Stevens, 1946, p. 677). This is not a straightforward matter: attitudes, traits, perceptions, opinions and abilities – whatever is in a person’s mind – cannot be measured in the same ways that physical objects are. The field of psychometrics aims to develop psychological measurement instruments with properties that resemble those of physical measuring. Using a ruler, two physical objects can be arranged according to length, and the ordering will be similar if they are measured twice on the same day. One unit is of the same size along the whole ruler, and the measurement is of equal precision anywhere on the ruler. It measures length, and only length, not taking weight, colour or texture into account. These properties might not seem impressive, but when it comes to psychological measurement they will never be reached perfectly.

*Invariance* is a key word in measurement. Invariant measures do not vary according to those who are selected to take the test: The persons – irrespective of their ability – agree on which items are easy and difficult. Equivalently, the items – irrespective of their difficulty – agree on which persons have high or low ability. To explain what ‘agree on’ means in this setting, Bond and Fox (2007) write the following: ‘Divide your sample of persons in two according to their ability and conduct item estimations for the total test for each half of the sample in turn. The invariance principle requires that the relative difficulties of the items should remain stable across the two substantially different subsamples’ (ibid., p. 71). Similarly, dividing the test in two, the person estimates based on the two subtests should provide the same relative ordering of person ability. Exemplifying the former, consider a mathematics test where the girls find item 1 harder than item 2 and the boys find item 2 harder than item 1. This violation of the invariance requirement indicates that one or both of the items somehow include the gender aspect in addition to mathematics skills. This is an unwanted property of a mathematics test. Thus, invariant measures are what psychometricians seek to develop – tests that only measure the trait about which inferences are drawn.

In 1945, the Danish government hired mathematician Georg Rasch to standardise an intelligence test (Howie, Kupari, Goy, Wendt, & Bos, 2011). Throughout the following years, his interest in psychological measurement grew and led him to develop probabilistic models for use in psychological and educational contexts. This culminated in the publication of *Probabilistic Models for some Intelligence and Attainment Tests* (Rasch, 1960). Based on
the ideas presented in that publication, Rasch theory has been developed in order to hold as many properties as possible similar to those of the ruler described above, so that teachers, psychologists, researchers and others interested in measurement can make sound and well-reasoned inferences about persons drawing on quantitative data. Many large-scale assessments, like the Programme for International Student Assessment (PISA) and the International Civic and Citizenship Education Study (ICCS), use the Rasch model, which is regarded as the fundamental model for international large-scale assessments of educational achievement (Wendt, Bos, & Goy, 2011). Many Rasch analysis computer programmes are available, and among the frequently used ones are RUMM 2030 (Andrich, Lyne, Sheridan, & Luo, 2011), ConQuest2 (Wu, Adams, Wilson, & Haldane, 2007), Winsteps (Linacre, 2012), and the freeware Construct Map (Kennedy, Wilson, Draney, Tutunciyan, & Vorp, 2011). RUMM 2030 is used to analyse data material in this thesis.

The introduction that follows will be given for the case when all items are dichotomous, that is, when all items in the test are scored either correct or incorrect. The theory extends to the polytomous case, for instance when responses are given using a Likert scale with more than two response categories or when responses are assigned partial credit. The simpler dichotomous case will suffice to present the main ideas of Rasch analysis.

**The mathematical model**

Imagine an infinitely long scale with ‘the amount of a trait’ increasing from left to right. A ‘trait’ might for instance be mathematics abilities, attitudes towards scientists or interest in technological careers. When a person is positioned on this scale, it reflects the person’s ability $B$, that is, how much of the trait the person possesses. When an item is positioned on this scale, it reflects the item’s difficulty $D$, defined as the amount of the trait needed to have 50% chance of getting the item correct. In Figure 2, a person with ability $B$ is placed on the scale together with five items having increasing difficulties $D_1, D_2, D_3, D_4$ and $D_5$:

![Figure 2: Person ability B and five items’ difficulties D1, D2, D3, D4 and D5 placed on a trait scale.](image-url)
Intuitively, we infer that the following holds for the person with ability $B$: the person is likely to get item 1 correct and *not* likely to get item 5 correct. The person will probably get item 2 correct, but might sometimes get it incorrect. Similarly, the person will probably *not* get item 4 correct, but might sometimes get it correct. And concerning item 3, there is 50% chance of getting the item correct.

The Rasch model is expressed mathematically. It satisfies the rationale in the above paragraph and other fundamental properties of measurement. The main equation in Rasch modelling will be given here to underscore the following: the probability of a correct response depends only on the difference between person ability and item. Specifically, for a person $i$ and item $n$, let $B$ denote ability, $D$ denote difficulty, $P$ denote the probability of an event and $X_{ni}$ denote the score person $i$ gets on item $n$ (0 if incorrect, 1 if correct). Then, a proper logistic function providing the probability of person $i$ with ability $B$ to correctly answer item $n$ with difficulty $D$ might be expressed by

$$P(X_{ni} = 1|B, D) = \frac{e^{(B-D)}}{1 + e^{(B-D)}}$$ \hspace{1cm} (1)

Equation 1, to which Andrich and Marias (2009) provide a nice introduction, is the starting point for the Rasch model. Both the person ability estimates $B$ and the item difficulty estimates $D$ are found by iterative processes drawing on Equation 1. The initial estimates of these iterative processes are given by the log of the odds (calculated from the total scores), which is the reason why a unit on the scale is called a *logit* (a log-unit). Graphically representing the function in Equation 1 with respect to the difference ($B - D$) in logits provides the following curve:

![Figure 3: Expected value curve given logit difference between ability $B$ and difficulty $D$.](image)
Three properties of the curve in Figure 3 will be mentioned here. Firstly, when person ability $B$ equals item difficulty $D$, there is a 50% chance of getting the item correct. As the ability increases relatively to the item difficulty, the expected value increases; there is a higher probability of answering the item correctly. Equivalently, the expected value decreases when the difficulty increases relatively to the ability.

Secondly, the curve converges at both ends. That is; no matter how high ability $B$, there is a chance of getting an item incorrect, and no matter how low the ability, there is a chance of getting an item correct. Moreover, an increase in ability in the lower or the higher ends of the scale does not lead to a great increase in expected value. For instance, a five-year-old training hard for a university calculus course will have a higher ability than other five-year-olds. But still, the chance of passing the university exam does not increase greatly – it is still close to zero. Similarly, a grown-up taking a primary school mathematics test will not benefit much from taking university calculus courses. The ability will increase, but the person would probably get a perfect test score either way. These two examples are graphically expressed by the flat ends of the curve.

Thirdly, the curve increases most steeply when ability $B$ is close to difficulty $D$. This is where the item discriminates the most: for persons with abilities close to the difficulty, the expected value increases greatly with increasing ability. That is; a small difference in ability leads to a great increase in probability of getting the item correct. The item separates persons with abilities in this region of the scale with precision. Little information is gained about persons in other parts of the scale. They will most likely get all items incorrect or all items correct, leaving limited information to separate between persons within these two groups.

Most commonly, the curve in Figure 3 is drawn with respect to a particular item using absolute Logit values on the x-axis, as opposed to the Logit difference used in Figure 3. The curve is then called the item characteristic curve (ICC). The curve is shifted to the left or to the right according to the difficulty $D$ of the item: by definition of difficulty, which is the ability needed to have 50% chance of answering the item correctly, the ICC is shifted so that the read-off value of $D$ is expected value of 0.5. For instance, Figure 4 shows the ICCs of two items, Item 1 and Item 2, with difficulties $D_1 = 0$ and $D_2 = 1.7$, respectively:
A person with ability $B = 2.2$ will, according to the two ICCs, have about a 90% chance of answering Item 1 correctly and about a 62% chance of answering Item 2 correctly. These values can also be found by inserting in Equation 1 $B = 2.2$, and $D_1 = 0$ and $D_2 = 1.7$, respectively.

The ICC provides useful insights into different Rasch analysis properties. Some examples of this will be given in the following subsection, where the properties used in Article III are presented. Given access to a variety of psychometric properties, one should keep in mind that statistics never make decisions. Statistics are used to inform discussion. Whenever data concerning an item does not fit the Rasch model – or any other model – with respect to theoretically derived properties, this does not necessarily exclude the item from the test. However, such statistics indicate that the item, and thus the total scale, does not meet requirements for measurement. This suggests that the item, the scale, and even the construct itself might need further investigation. The item and scale statistics and graphics provided by different Rasch software give clues about where to start the investigation. Thus, Rasch modelling is a model-driven approach to measurement; the collected data is investigated using a model that is theoretically and mathematically derived from fundamental properties of measurement. This philosophy is often contrasted against a data-driven approach to measurement, where models are developed in order to describe the collected data as accurately as possible. That is; in the former case, the instrument is developed in order to produce data that fits a model, while in the latter, the model is developed in order to fit the collected data. Pursuing a model-driven approach, the following properties are derived from the Rasch model to support the development of invariant measures satisfying fundamental requirements of measurement.
Rasch analysis properties

Property 1: Persons and items on the same interval scale: Person-item maps

According to the Rasch model, the only two variables influencing the probability of a correct response should be person ability and item difficulty. The fact that the logit scale is an interval scale is of great importance in this respect. The steps on an interval scale are of equal size across the scale. Thus, we can calculate the probability of a particular person answering a particular item correctly (Andrich, 1988), irrespective of where on the scale the ability and difficulty estimates are. That is; as long as \((B_1 - D_1) = (B_2 - D_2)\) then 
\[
P(X_{ni} = 1 | B_1, D_1) = P(X_{ni} = 1 | B_2, D_2).
\]
This would not necessarily be true if the steps on the logit scale were of unequal size.

A useful property of having persons and items on the same scale is the opportunity for informative test overviews. Such an overview is provided by person-item maps, as displayed in the following figures:

Figure 5: Person-item map for a test, indicating that the test is relatively well-targeted. Illustration from Rasch software RUMM 2030.

Figure 6: Person-item map for a test, indicating that the test is too easy. Illustration from Rasch software RUMM 2030.
Drawing on person-item maps, one can investigate the extent to which the items are suitable for the test-takers. In Figure 5, person estimates and item estimates coincide quite well. As discussed in the third property of the item characteristic curve, most information about test-takers is provided by items in the same region on the logit scale. Thus, this test seems to be well-targeted. The test inspected in Figure 6, however, has most items with estimates lower on the logit scale than most person estimates. Thus, the test might be regarded as too easy for the test-takers. With regard to test efficiency, many of these items might be redundant as there are several items discriminating in a part of the scale where few persons are located. Too few items separate between the many persons higher on the logit scale.

Property 2: Person separation index (PSI)

The person separation index (PSI) provided by the RUMM software is an index often compared to Cronbach’s alpha, where the logit values replace the raw scores used in estimation (Tennant & Conaghan, 2007). The PSI takes on values between 0 and 1, and it indicates the degree to which a test is able to separate persons with regard to ability. That is; it is a measure of person order replicability (Bond & Fox, 2007). The PSI and Cronbach’s alpha estimates for a set of items most often turn out to be quite similar.

The PSI depends on the spread of items and persons along the continuum, which might be investigated in person-item maps. If many persons have similar ability estimates, then many items around this location on the logit scale are necessary to separate the persons with precision. Note that the spread of items and persons on the logit scale implies a variation in how much information is gained about persons and items. Thus, individual error estimates are calculated for each person and each item. This is a valuable property of the Rasch model, which will be utilised in investigating unidimensionality (Property 5).

Property 3: Person fit and item fit

According to Equation 1, the probability of answering correctly decreases as the item difficulty increases. Thus, ordering the items according to increasing difficulty should provide a response pattern close to the Guttman pattern (Bond & Fox, 2007). A perfect Guttman pattern occurs when all items are answered correctly up to a certain difficulty, and all remaining items are answered incorrectly. In reality, since the Rasch model is probabilistic, the perfect Guttman pattern is unlikely. It is more likely to be ‘Guttman-like’: up to a certain point, most items are answered correctly, and from a certain other point, most
items are answered incorrectly. In between these two points are the items with difficulties close to the persons’ ability, where correct and incorrect responses are more randomly distributed.

The *person fit* estimate provides information about how similar to the Guttman pattern a person’s response pattern is. If, say, a person gets many easy items wrong and many hard items correct, this would be labelled as *under-fit* and calls for a further investigation of this person’s responses. Many effects might cause such patterns, like respondents’ motivation, situational distractions, guessing and cheating, and these effects are all unwanted. On the other hand, *over-fit* occurs when a response pattern is *too similar* to the Guttman pattern. This might indicate that the items are all either too easy or too hard, with no items in the range where the person is located, or that the person has been able to cheat up to a certain point in the test.

Moreover, grouping persons according to ability estimates provides the opportunity to investigate *item fit* (Styles & Andrich, 1993), that is, how the items fit the Rasch model: Are the observed group values close to the values suggested by the item characteristic curve? For instance, if all the respondents are divided into five groups with mean abilities $B_1, B_2, B_3, B_4$ and $B_5$, then based on the observed values in the five groups we calculate the observed mean value for each group. These are plotted together with the ICC:

![Figure 7: Item characteristic curve for item with difficulty $D=0$ and five observed group mean values.](image)

If the observed values are close to the expected values given by the ICC, then this indicates that the item fits the Rasch model. The item displayed in Figure 7 fits the Rasch model well, having observed group mean values close to the ICC. Below are two different ways items might *not* fit the Rasch model, that is, two items that ‘misfit’:
The item in Figure 8 under-discriminates; it does not discriminate well between any of the test-takers. The fact that persons in the group with mean ability estimate of 0 have a higher observed mean value than persons in the group with mean ability estimate of 0.8 indicates that the item to a small extent concerns the trait ordering the persons. An item that under-discriminates provides little information about how the persons should be ordered according to the trait. Turning to Figure 9, this item over-discriminates; the expected value increases greatly in a certain region of the logit scale. Thus, it discriminates well among test-takers with ability estimates between -1.0 and 1.0 but contains little or no information about persons outside this interval. It would not provide information about the difference between persons below -1.0 logits, as most of these would get the item wrong, or about the difference between persons above 1.0 logits, as most of these would get the item correct.

Estimation procedures for both person fit and item fit differ between Rasch analysis computer programmes. In RUMM 2030, fit to the Rasch model is inspected by looking at fit residuals. These are estimated by taking the standardised sum of the differences between a person’s or an item’s observed values and the theoretically expected values summed over all
items or persons, respectively. The suggested cut-off points for person and item fit residuals are – 2.5 (under-fit) and + 2.5 (over-fit). Other fit estimates are, for instance, the ‘infit’ and ‘outfit’ measures provided by many Rasch computer programmes, where the infit statistics give more weight to items and persons close on the Logit scale. These statistics are more robust against the influence of outliers than the outfit statistics, which do not weight items or persons (Bond & Fox, 2007).

**Property 4: Differential item functioning (DIF)**

Rasch theory is frequently used in international comparative surveys. Differential item functioning (DIF) is a highly valued property for the developers of these tests (Schulz & Fraillon, 2011; Stubbe, 2011). Test developers investigate DIF to make sure that persons with the same ability have the same probability of answering an item correctly, irrespective of attributes like gender or nationality (Hagquist & Andrich, 2004). For instance, girls with ability $B_{girl}$ should have the same probability of correct response to an item as boys with similar ability $B_{boy} = B_{girl}$. If not, then the item measures something besides the focal trait that happens to be correlated to gender, that is, it ‘measures gender’, violating the invariance requirement. Graphically, DIF is investigated by comparing the observed values between groups similar in ability but different with respect to an attribute. Two instances of DIF are visualised in Figure 10 and Figure 11, where the attribute under investigation is nationality:

![Figure 10: Item characteristic curve, observed group mean values for Danish and Swedish respondents showing uniform differential item functioning (DIF).](image-url)
The item in Figure 10 is an example of uniform DIF, where all Swedish ability groups have a higher expected value than all respective Danish ability groups. That is; Swedish respondents score consistently higher on this particular item than the Danish respondents, even though their overall test scores are the same. This means that the responses to this particular item not only depend on ability, but also on something related to nationality. This should be investigated further.

The item in Figure 11 exemplifies non-uniform DIF. In this instance, the item discriminates differently between persons within the nationalities. Consequently, it differs in the amount of information it provides about persons, due to some attribute besides ability. This violates the invariance principle, and the item needs further investigation.

Gender and nationality are typical attributes for which DIF might be investigated.

**Property 5: Tests for unidimensionality**

Unidimensionality (Gardner, 1996; Tennant & Pallant, 2006) is a key word in Rasch theory. Only the trait being investigated should influence the responses to an item. This trait might, indeed, be multidimensional. For instance, the mathematics trait might be regarded as consisting of an algebra dimension, a geometry dimension, and so forth. However, the scale developed to measure this trait should be unidimensional, where the amount of the (possibly multidimensional) trait is the only thing influencing the location on this scale. Invariant measures produce unidimensional data; meaning that when the effect of the trait is removed, nothing but uncorrelated residuals should be left in the data. If data are not unidimensional, this indicates that the items need further investigation, as they might not contribute positively the development of an invariant measure. Note that unidimensionality is not
something that can be ‘proven’ statistically. It has to be argued for, drawing on both statistical results and theoretical considerations.

RUMM 2030 offers tailored statistics to include in a unidimensionality argument: person ability estimates are calculated from the person’s responses, and accordingly, the persons have individual expected values for each item. The differences between the persons’ observed values and their expected values are plotted in a person-by-item residual matrix. Thus, the effect of the trait has been ‘removed’, and the information contained in the matrix should be random and uncorrelated. That is; if the trait of interest is the only thing systematically measured by the test, then removing the effect of this trait from the responses should lead to nothing but random residuals. A principal component analysis (PCA) conducted on this residual matrix might thus indicate whether or not other dimensions systematically influence responses, which would violate the invariance requirement. The PCA returns collections of items from the test based on residual correlations. Independent t-tests might then be conducted for each person on the different collections of items. This is possible due to the fact that in Rasch analysis, unique measurement errors are calculated for each person. Specifically, RUMM 2030 attributes each person with unique ability and error estimates for the collection of items in the first component and for the items not contained in this component. Independent t-tests are then conducted for each person. Tennant and Conaghan (2007) suggest that if more than 5% of the respondents have significantly different scores on the components suggested by the PCA, then the test should be investigated further. The residuals are supposed to be uncorrelated, but correlations are found between certain items’ residuals. This indicates that these items have something in common influencing the test-takers’ responses besides the focal trait.

Property 6: Threshold curves in polytomous models

The presentation so far has evolved around the case of a test with dichotomous items, with responses scored 1 if correct or 0 if incorrect. Rasch theory does, however, apply to several other settings. Firstly, it extends to tests with polytomous items, where responses are scored using more than the two categories ‘correct’ and ‘incorrect’. For instance, a response might be partially correct, as when test scorers assign 0 for incorrect, 1 for partially correct, and 2 for correct. Polytomous items might have as many score categories as the persons giving the test find useful. Secondly, as previously mentioned, Rasch theory does not only apply to tests of ability, but to all instances where a construct – a ‘postulated attribute of people’
(Cronbach & Meehl, 1955, p. 283) – is measured. In developing instruments where attitudes, perceptions and opinions are measured, Rasch theory might contribute greatly (Masters, 1982). Conclusively, polytomous Rasch models are important extensions of the dichotomous case, and these are frequently used in research on abilities, attitudes, perceptions and opinions, for instance on PISA questionnaire data (OECD, 2009b). Many attitude questionnaires have items where responses are given by marking off in one of four, five or more boxes, indicating the amount of agreement to a statement or the frequency of certain events.

Two polytomous Rasch models exist, namely the partial credit model and rating scale model (Wright & Masters, 1982). The main difference between the two concerns the thresholds – the points on the logit scale where chance of responding in two adjacent response categories is equal. In the partial credit model (Masters, 1982) the distances between thresholds are allowed to vary between items, while in the rating scale model (Andrich, 1978) these distances are kept constant for all items in the test. The rating scale model thus assumes that the respondents use the scale similarly for all items measuring the same trait. Given two such items, a respondent needs the same increase in ability to go from starting to embrace category 2 to starting to embrace category 3 for both items. Put simply; category 2 covers the same length of the ability scale for all items. Which part of the scale the item covers, however, depends on the item difficulty.

Whenever a partial credit model is applied, it is particularly important to inspect whether the successive response categories reflect an increase in ability. This is investigated by looking at the ordering of thresholds, visualised by drawing the probability curves for the different response categories:
In the above figure it is evident that as the ability increases, so does the probability of responding in increasingly higher response categories. A useful property of polytomous Rasch models in this respect is the opportunity to reveal redundant or biased response categories. These are indicated by the occurrence of reversed thresholds, two of which are exemplified here:

Figure 13: Item with disordered thresholds. Illustration from Rasch software RUMM 2030.

Figure 14: Item with disordered thresholds. Illustration from Rasch software RUMM 2030.
The threshold between response Category 0 and 1 in Figure 13 is located at -0.2 logit, while the threshold between Category 1 and Category 2 is located at -2.4 logit, that is, the successive thresholds are reversed. Category 1 is not the most likely response for any person. The respondents that move from Category 0 seem to naturally embrace Category 2, indicating either that there are too many response categories, or that the trait being measured naturally develops from Category 0 directly to Category 2. In this instance, one could consider collapsing the five response categories into four. In Figure 14, the thresholds of the mid-category are reversed. A challenge with neutral mid-categories is that they might be used as ‘I don’t care’ or ‘Does not apply to me’ responses (Kulas et al., 2008), which might be applied by persons with different ability estimates. If a test has many reversed thresholds for the mid-categories, then having an odd number of response categories on this test might be reconsidered.

Note that in psychometric literature, reversed thresholds are sometimes referred to as reversed step difficulties. In the latter contexts, thresholds are defined as the points on the logit scale where there is an equal chance of responding in one category as in any of the higher categories, and not only in the successive category.

Reversed thresholds might occur for different reasons, like redundant response categories, multidimensionality and too few responses. For instance, if a response category defines a level of the trait that hardly exists conceptually or that is contained in a successive response category, this will receive few responses, which might lead to reversed thresholds. Thus, as for all other Rasch properties mentioned in this introduction, these statistics should encourage further investigation of the instrument, in order for the test developers to identify the reasons behind unexpected response patterns.

**Using Rasch theory in developing the questionnaire instrument in Article III**

The third article in this thesis concerns the development of a psychometric instrument called SPIAS – Significant Person Influence on Attitudes towards STEM. Drawing on Woelfel and Haller (1971), who define four ways that significant persons influence attitudes, the instrument measures how the participants in the mentoring project ENT3R perceive their mentors with respect to these four constructs. The items in SPIAS are phrased using expressions and terms that occurred frequently in a total of seven focus group interviews with ENT3R participants, four of which are described in Article II. The three additional
focus groups were conducted with a modified version of the interview guide (Appendix 5), focusing merely on the mentors. In addition to their contribution in focus groups, the ENT3R participants were the target group for the pilot version of SPIAS (Appendix 6).

Through this introduction to Rasch theory, terminology and key terms have been explained more properly than what is possible in the article format. In developing SPIAS, Rasch theory was used due to the many important properties mentioned in the above introduction: the items have to fit the persons taking the test, and responses should not be affected by attributes like gender. The scale must be interpreted similarly across items, and thus the rating scale model was chosen. In particular, dimensionality issues were important, making it possible to precisely measure the four different constructs suggested by Woelfel and Haller. Conclusively, the introduction to Rasch theory provided here presents different properties that were desirable in developing SPIAS. These properties are part of the rationale for using Rasch modelling in Article III.
4. SUMMARY OF THE THREE ARTICLES
4.1. Succession of the three articles

A summary of the three articles in this thesis will be provided here. They are ordered both chronologically, according to when the articles were written, and thematically, from the general to the specific. In the first article, STEM students share their considerations about significant persons who inspired their educational choice. Persons with whom one stands in an interpersonal relationship, like parents and teachers, stand out as inspirational sources. In the second article, a specific group of such persons is investigated: the mentors in a mentoring project. Finally, the third article is committed to developing a questionnaire instrument to measure significant person influence. This is developed specifically for the mentoring project, but might be adapted to other settings.
4.2. Article I: ‘Sources of inspiration: The role of significant persons in young people’s choice of science in higher education’

Background, theory and methods

This article draws on questionnaire data from project Lily. Responses to closed and open-ended questions of 5007 STEM students are analysed to investigate significant persons’ influence on tertiary educational choices. Focus is put on parents and teachers, and their influence on STEM educational choices are described using the framework suggested by Woelfel and Haller.

Results

About 40% of the respondents claim that one or more significant persons have inspired their educational choice to a ‘great extent’, and 30% choose to write about persons in the open-ended questions. First and foremost, the respondents in project Lily highlight persons they know personally or with whom they have had a personal meeting. Compared to celebrities, friends, siblings, and other persons, the Lily respondents give special attention to parents and teachers. Parents receive the highest scores in the closed questions and are often mentioned in the open-ended questions. Teachers as a group are not rated highly in the closed questions, but they are the most frequently mentioned persons in the open-ended questions.

On average, females credit all groups of significant persons, except celebrities, with more inspiration for their educational choice than do males. In the open-ended questions they include other persons in their stories far more frequently. Females are, for instance, more than twice as likely to write about a teacher. In descriptions about parents, fathers are mentioned more than six times as frequently as mothers. Moreover, about every second student with no STEM-educated parents responds in the top two categories to indicate the degree of inspiration from parents for the educational choice.

Students in disciplines that also exist as subjects in school – mathematics, physics, chemistry and biology – are the most likely to report inspiration from their teachers, far more frequently than students in applied STEM subjects, such as computer science, engineering and geosciences. For instance, every third chemistry student claims to be
inspired by a teacher to a great extent, while every 25th computer science student claims likewise.

Drawing on responses to open-ended questions, the ways that parents and teachers have inspired Lily respondents to choose STEM is described using the framework of Woelfel and Haller. In defining the self, parents communicate youngsters’ main characteristics and general self-knowledge, including expectations held of them. Parents thus influence their global self-views, while teachers more commonly influence their specific self-views: teachers help students learn about and develop their skills and abilities in certain subjects. In defining STEM, both parents and teachers most commonly share information about a subject, an education or a career they themselves have first-hand knowledge about. Notably, different respondents highlight different pieces of information as relevant to them. In modelling a self, many parents are role models and inspire their children to pursue a similar education as they themselves once pursued. Teachers impress their students with competence, engagement and sometimes simply by being a great person. This way, they show many students how participation in STEM can be an integral part of an identity in a positive way, thus increasing the spectrum of attractive and suitable roles within STEM. In modelling STEM, parents often introduce future students to the subjects through different activities, including tinkering and workplace visits. This provides youngsters with experiences related to specific careers. Teachers, on the other hand, more often provide experiences with STEM in general, showing fun and enjoyable aspects of different subjects.

Conclusions and implications

Many fathers are mentioned in the open-ended questions compared to mothers, which might indicate a strong role model effect, as men are highly overrepresented in most STEM careers in Norway. On the other hand, parents might also inspire a choice of STEM without being STEM practitioners. For instance, those who know the youngsters personally are in a special position to provide the future student with self-knowledge and information the student finds relevant. The recurring theme in the article is how the ones who know girls and boys personally hold particularly important roles as sources of inspiration. Anyone seeking to influence young people’s attitudes towards STEM should look for ways to involve those who know the girls and boys personally. Moreover, the Woelfel and Haller framework is found suitable for discussing various ways significant persons influence young people’s choice of STEM.
4.3. Article II: ‘Increased motivation for science careers? Investigating a mentoring project’

Background, theory and methods

Article II concerns the ENT3R project; a Norwegian mentoring project where 15- to 19-year-olds come to their local university or university college once a week for ‘maths trainings’. These maths trainings are led by tertiary STEM students – mentors – who arrange STEM-related activities. Through these trainings and monthly ‘career nights’, the ENT3R mentors seek to provide youngsters with science role models, improve their STEM competence and confidence, and allow them to see the utility of STEM. The main goal is to enable the youngsters to get to know STEM students personally.

The following questions were investigated in Article II: What do the participants appreciate about the project? And in what ways might ENT3R influence participants’ choice of education? Focus group interviews with 25 of the participants in ENT3R at the University of Oslo were conducted to answer these questions. All informants had participated for at least one semester. Thus, the data is collected from persons assumed to enjoy the project. The first question was answered drawing on open coding of the focus group transcriptions, while the second question was answered drawing on coding according to Eccles and colleagues’ expectancy-value model (Eccles et al., 1983).

Results

The mentors play a lead role when ENT3R participants share their positive experiences of the project. Firstly, the mentors provide good teaching. It is highlighted that they have both content knowledge and good pedagogical skills, and they spend a lot of time individually guiding the participants. Secondly, the mentors create a positive atmosphere. The mentors are described as flexible, open and often humorous, and the participants feel free to be honest about their skills and about struggling with maths. Thirdly, the mentors engage in interpersonal relationships. This is highlighted by many participants as the single best thing about the project. They perceive their mentors as friends, and feel that the mentors care for them personally. Finally, the mentors are positive role models. This is implicit in the three former factors and is emphasised by participants who describe how the mentors counter the unfavourable stereotypes concerning STEM persons.
Respondents describe different experiences where ENT3R mentors seem to promote a subsequent choice of educations within STEM. *Expectation of success* is heightened for some participants by mentors teaching new techniques, revising old techniques and encouraging them to be persistent. *Attainment value* might be increased by mentors who counter stereotypes, who are role models, and who show enjoyable STEM student lifestyles. The fact that many participants perceive their mentors as friends has made it more personally important for some to perform well in mathematics. Some report increased *interest-enjoyment value* due to mentors providing enjoyable experiences with maths, including fun presentations and mastery experiences. *Utility value* has increased for some participants, as they are provided with information about different careers and get to learn about the personal benefits of pursuing STEM educations. Finally, the *relative cost* of choosing STEM is reduced for some participants. The mentors emphasise that it is okay to struggle with mathematics, and they show the participants that being a STEM student does not necessarily reduce the quality of a social life.

**Conclusions and implications**

From the experiences shared by participants in ENT3R, it seems reasonable to assume that ENT3R strongly and positively influences some participants’ motivation for STEM educations and careers. In fact, several participants state this explicitly. Most of the factors pointed to in Article II strongly relate to the STEM university students employed as mentors. The ones who engage in close interpersonal relationships are particularly highlighted in the focus groups. By offering a variety of experiences and following the participants over several years, the mentors hold important roles in the complex and ongoing process that educational choices are for persons in this age group. Results of this research point to the necessity of out-of-school projects that heighten the total exposure to STEM. The benefits of evaluating and adjusting such projects are evident, and the importance of selecting mentors carefully is emphasised. This is done through a thorough application process in ENT3R, where applicants’ content knowledge, pedagogical skills and personal suitability are examined.
4.4. Article III: ‘Measuring the ways significant persons influence attitudes towards science and mathematics’

Background, theory and methods

The questionnaire instrument ‘Significant Person Influence on Attitudes towards STEM’ (SPIAS) is developed in Article III. The development draws on Nauta and Kokaly’s (2001) work with the ‘Influence of Others on Academic and Career Decisions Scale’ and Woelfel and Haller’s (1971) definition of significant persons. According to this definition, attitudes result from individuals’ conceptions of both their selves and the attitude objects. The relationships between these conceptions constitute the attitudes. Anyone who through direct interaction (definers) or by example (models) influences an individual’s conception of self or object, influences the individual’s attitudes.

The four modes of significant person influence are derived from Woelfel and Haller’s definition, namely, defining the self, defining the object, modelling a self and modelling the object. In developing SPIAS, responses to particular sets of items are combined to form scales in order to measure these ways of being a significant person. Phrases and expressions that appeared frequently in the seven focus groups with participants in the mathematics mentoring project ENT3R (described in Article II) are used in wording items, and the pilot study is conducted with 114 ENT3R participants. On five occasions, two to three students took part in a discussion concerning the pilot version immediately after they had completed the questionnaire. The development of SPIAS from 31 pilot study items to the final 17 items is guided by feedback provided in these discussions, Rasch analysis using computer software RUMM 2030, and theoretical considerations.
Results

The 17 items given in Table 1 constitute the final version of SPIAS.

Table 1: The 17 items in the final version of Significant Person Influence on Attitudes towards STEM. Items 1-4 and 9-12 are given under the heading ‘To which extent do the following statements apply?’ and items 5-8 and 13-17 are given under the heading ‘To which extent have you experienced that your mentors have done the following?’ Responses are given on a four-point Likert scale from ‘small extent’ to ‘large extent’, where the two mid categories are unlabelled.

<table>
<thead>
<tr>
<th>Item</th>
<th>Defining the self</th>
<th>Modelling a self</th>
<th>Modelling STEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The mentors have been important for how much self-confidence I have in maths</td>
<td>The mentors have shown me whether it fits me to be a STEM student</td>
<td>Shown new sides of maths</td>
</tr>
<tr>
<td>2</td>
<td>The mentors have been important for how well I understand maths</td>
<td>I have an impression of what the mentors are like as persons</td>
<td>Shown examples of how maths can be applied</td>
</tr>
<tr>
<td>3</td>
<td>The mentors have been important for how much I enjoy doing maths</td>
<td>The mentors have shown me examples of what kind of qualities STEM students can have</td>
<td>Shown maths from a new perspective</td>
</tr>
<tr>
<td>4</td>
<td>The mentors have contributed so that I have discovered my abilities in maths</td>
<td>I have an impression of how the mentors experience their studies</td>
<td>Shown interesting maths examples</td>
</tr>
<tr>
<td></td>
<td><strong>Defining STEM</strong></td>
<td><strong>Modelling a self</strong></td>
<td><strong>Modelling STEM</strong></td>
</tr>
<tr>
<td>5</td>
<td>Talked about careers I can get with an education in STEM</td>
<td>Shown new sides of maths</td>
<td>Shown new ways to solve maths exercises</td>
</tr>
<tr>
<td>6</td>
<td>Talked about different studies I can take within STEM</td>
<td>Shown examples of how maths can be applied</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Talked about what I can use STEM for</td>
<td>Shown maths from a new perspective</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Talked about the role of STEM in society</td>
<td>Shown interesting maths examples</td>
<td></td>
</tr>
</tbody>
</table>

According to Rasch analyses, the inspected psychometric properties of these four collections of items are satisfactory. Person separation indexes are high, no thresholds are reversed, no differential item functioning with respect to gender is observed, and all items have reasonable fit and a nice variation in location. Principal component analyses of the four constructs indicate that the pilot study data are unidimensional. Moreover, an analysis of all 17 items put together confirms that the constructs do not overlap. This analysis indicates relationships between the Defining the self and Modelling the object construct measures and likewise the Modelling a self and Defining the object construct measures.

Conclusions and implications

In addition to the self/object and defining/modelling dualities, a third duality related to significant person influence is suggested in Article III, namely, an introspective-extrospective duality. The Defining the self and Modelling the object construct measures concern ‘my STEM self-concept and my experiences with STEM’ (introspection), whereas
Defining the object and Modelling a self concern ‘what STEM persons are like and what they are occupied with’ (extrospection).

SPIAS holds good psychometric properties and draws on theoretical considerations. It is developed in the context of a Norwegian mentoring project where 15- to 19-year-old participants meet tertiary STEM students for weekly maths trainings, but might be applied and developed for use in other contexts and countries. The inclusion of such an instrument in post-tests in attitude studies might provide insight into how the significant persons involved in an intervention contribute to attitude change.
5. DISCUSSION
5.1. Overview

This discussion will proceed as follows: in Section 5.2, results will be summarised indicating that significant persons are, indeed, significant for attitudes and educational choices. The personal meetings will be emphasised. Three groups of significant persons will be elaborated on in the following sections (5.3-5.5), namely parents, teachers and publicly known persons.

A general discussion concerning significant persons and how they contribute to young people’s identity processes is provided in Section 5.6. In Section 5.7, limitations of this research and suggestions for future research are discussed. Implications of this thesis are drawn in Section 5.8. Finally, in Section 5.9, the overall aim and the research questions of this thesis are revisited and conclusions are drawn.

Throughout the following discussion, one should keep in mind that ‘significant persons’ is only one piece of a major jigsaw puzzle. Educational choices are complex. Indeed, other persons are significant in these processes, but so are cultural patterns and values, self-developed interests, isolated events, mere coincidences, and so forth. It is important to look at the issue of participation in STEM from different viewpoints, for instance with a focus on gender, recruitment initiatives, or theoretical models for choice. The influence of significant persons is one of the factors that should be investigated; they are part of the overall effort to support young people in getting to know themselves and their opportunities in STEM educations and careers.
5.2. Significant persons’ significance on attitudes and educational choice

Attitudes and attitude development

This thesis revolves around the idea that significant persons influence young people’s attitudes towards STEM. It is described in Article I that significant persons are significant parts of the educational choice. In Article I and Article II, the different ways that these persons exert influence are elaborated on, and in Article III, it is explored how this influence might be measured. However, drawing implications from these results and acting on them is no guarantee for success in terms of increased participation, as attitude change is not a straightforward matter. Attitudes, as defined by Woelfel and Haller, are rarely influenced directly. They are contingent on the individual’s conception of self and the individual’s conception of the attitude object. Different individuals might draw on different sources of information when these conceptions, and thus the implied attitudes, are developed. The weight given to different pieces of information varies: some attitudes are based mostly on positive experiences with the object, some are based mostly on information about the object, some are based mostly on the individual’s self-view, and some are based mostly on the impression of those who relate to the object. Persons might provide information about the individual or the attitude object, but whether or not this will be used by the individual to change conceptions of self and objects – and thus attitudes – cannot be predicted.

Moreover, Fishbein and Ajzen (1975) claim that it is difficult to identify which attitudes are influenced in interaction. They state that ‘it is not at all clear what new beliefs the subject might be expected to form or which of his existing beliefs are likely to change’ (p. 415). For instance, a person from an oil company giving a presentation at school can change Student 1’s attitudes towards STEM educated people, Student 2’s attitudes towards the oil industry, and Student 3’s attitudes towards people using PowerPoint presentations. Many factors influence how the different individuals perceive the person, like recent experiences at home, the topic discussed with friends in the minutes before the presentation, and how the person is introduced by the teacher. Conclusively, we cannot know beforehand how individuals will process new stimuli provided by a significant person, which conceptions the individual activates, or whether the information will be weighted sufficiently to change any conceptions. Discussions about attitude change in general, and attitude change with regard to STEM in particular, must always take this uncertainty into account. Changing attitudes
towards STEM is not a deterministic, but a probabilistic matter. This point is made clear in Article II, where it is discussed whether or not the mentors increase the *probability* of ENT3R participants choosing STEM educations.

Significant persons are significant in that they influence conceptions of self or attitude objects, which might happen through defining or modelling. These two dualities are good starting points for discussing attitude change. In Article III, a third duality by which attitude change can be explored is suggested: extrospection and introspection. Extrospection involves sensing; touching, tasting, smelling, looking and listening. Through extrospection, the individual identifies factors that are available to any other outside observer: What are the persons like that are engaged in this? How do they live their lives? What opportunities are provided for those who do this? What do people learn by engaging in this? These questions are answered by persons ‘defining the object’ and ‘modelling a self’.

While extrospection is related to external observations that are *accessible to all*, introspection involves everything individuals might consider *their own*. Historically, the concept of introspection emerged in psychology and concerns the process of ‘looking into our own minds and reporting what we there discover’ (Boring, 1953, p. 170). The term has been used similarly in social psychology. For instance, Fiske (2010) identifies introspection as one of the four main processes involved in the emergence and development of the self-concept, describing it as the analysis of one’s own thoughts and feelings in order to learn about oneself. Attitudes might develop through introspection, as individuals look inward to identify factors that are specific to them. Am I good at this? Am I able to complete this? Do I have any particular experiences with this? Have I enjoyed taking part in similar activities?

Simply put, introspection with regard to STEM participation explores ‘my STEM self-concept and my experiences with STEM’, which are included in what Woelfel and Haller called ‘defining the self’ and ‘modelling the object’. Indeed, there are sliding transitions here. For instance, when an object is being modelled, as when physics teachers demonstrate the effect of liquid nitrogen on flowers, this is observed and accessible to the rest of the class as well. On the other hand, the presentation is experienced differently by different students and is included in the collection of ‘my experiences with the object’. This collection differs from person to person, and has to be introspectively observed.
Significant persons’ influence on educational choice

This thesis does not only concern attitudes towards STEM, but also choice of STEM educations. Concerning the latter, the Norwegian youth culture stresses that educational choice is purely your own, that you are free to choose whatever you want, and that no external factors like tradition or family expectations should influence that decision (Schreiner, 2006). However, results presented in this thesis show that young people’s choice of educations within STEM are indeed influenced by other persons. Considering the number of persons with STEM education in Norway, the fact that almost 50% of the STEM respondents in project Lily have at least one STEM educated parent indicates that there is a strong relationship between students’ educational choices and their parents’ education. Moreover, about 40% of the respondents claim that one or more significant persons inspired their educational choice to a great extent, and 30% chose to write about persons when describing their choice. Conclusively, at least every third STEM student holds up one or several significant persons as key players in their choice of education. Significant persons are, indeed, significant.

However, unambiguous conclusions are difficult to draw based on these figures from project Lily. For instance, nine out of ten Lily respondents claim that the opportunity to work with something they are ‘interested in’ is a very important factor in a future job (Schreiner et al., 2010). One could conclude that the focus thus should be on this aspect in promoting STEM and not on significant persons. However, one might argue that significant persons in some sense are implicit in a variety of reasons for choosing STEM, as pointed to in this thesis: interests are often developed socially, in processes including siblings, friends, teachers and parents. Perceptions of STEM are transmitted through persons in the media, self-knowledge arises in interaction with other persons, and values emerge that are highly related to caretakers’ values and behaviours.

Moreover, as emphasised in Article II, the educational choice might be regarded as a process. Indeed, certain moments in young persons’ lives are decisive with regard to educational choices, for instance the day when students have to choose specialisation in upper secondary and the day when applications for tertiary educations must be submitted. Adolescents’ conceptions of themselves and the subjects in these moments might greatly influence their lives. However, interests, perceptions of STEM, self-knowledge and values develop continuously, influencing how the individual considers different educational
opportunities. In line with the symbolic interactionist perspective, where it is claimed that conceptions of self and attitude objects are developed in interaction, Holmegaard, Ulriksen and Madsen (2012) use narrative psychology to investigate STEM educational choices. ‘Narratives’ in this tradition are stories persons create about themselves to frame events and choices in a coherent fashion. Such stories, structuring the world in ways the individual experiences as meaningful, are constantly negotiated with other persons. The surroundings’ reactions to the narratives help the individual to confirm, revise or reject certain stories. That is; even though adolescents make educational choices independently and based on their own interests, their narratives about these choices are ‘tested out’ on significant persons beforehand. How the significant persons consider the suitability of different choices is communicated in interaction with the individual – often subconsciously and over years. The respondents in project Lily and the participants in ENT3R provide glimpses of such negotiation processes. Family members have exemplified how certain careers fit ‘who we are in our family’, teachers have contributed to constructing a narrative about the student having the skills necessary for a demanding education, and sociable STEM students have made it easier to tell the story about ‘the enjoyable life I will have as a STEM student’.

Two things, then, are learned from the present data about significant person influence: (1) a considerable number of students are aware that other persons are important to their educational choices and (2) their insight helps us understand this influence more deeply and enables us to provide other girls and boys with similar experiences.

**The personal meeting**

Before discussing parents, teachers and celebrities separately, a major result in this thesis is exemplified: it concerns the personal meeting. School visits are part of the marketing strategy of the Norwegian University of Science and Technology (NTNU). NTNU students visit schools in the region to share about their lives as STEM students at this institution. In the Lily questionnaire administered to upper secondary students (Bøe, 2012), three respondents wrote the following when asked about why they chose to pursue science and mathematics in upper secondary:
Lectures by NTNU persons, my dad and Knut Jørgen Røed Ødegård [Norwegian astronomer].

A student came from the university in Trondheim [NTNU] to our school and told about his life as a science student there.

Lecture by a NTNU student.

In investigating these responses, Bøe discovered the following: the quotes stem from three students who were in the same class in upper secondary (Schreiner et al., 2010), that is, they all describe the same person. This NTNU student made such an impression that three individuals later came to include the student in the story about their educational choice. The power of the personal meeting is evident in these quotes, as in many of the results presented in this thesis. Respondents in project Lily highlight how parents and teachers in different ways have played a part in their educational choices. Moreover, participants in the mentoring project ENT3R share stories indicating the importance of interpersonal relationships with STEM role models. Conclusively, the personal meetings are decisive. This is in line with research describing how persons are more likely to be perceived as role models when they get to know the youngsters personally (Buck et al., 2008), and where it is suggested that support and guidance is a major part of the influence on educational choices (Nauta & Kokaly, 2001). ‘Teachers showing an interest in students as persons’ was one of the three highly powerful predictors in regression models concerning attitudes towards physics and concerning choice of A-level physics in upper secondary schools in Denmark (Krogh & Thomsen, 2005). Moreover, in the recruitment effort investigated by Cantrell and Ewing-Taylor (2009), the social hours following STEM practitioners’ career presentations were regarded as the most powerful experiences: ‘It was during the social hours that students crowded around the speakers, asked questions, received more personalised experience with various apparatus and equipment and talked informally about what it was like to do what the speaker did for a living’ (p. 300).

It is no surprise that those who stand in interpersonal relationships with young people – like parents and teachers – influence their educational choices. Still, it is important to examine this ‘obvious’ fact. On one hand, it is important to confirm that it is true also for current Norwegian adolescents choosing specialisation in upper secondary school or tertiary STEM educations. Moreover, Lazarsfeld’s scheme, described in the introduction to social
psychology, could very well be executed with the data material in this thesis. If, say, the results indicated that physics teachers were unimportant for students’ educational choices, this would be obvious: ‘You don’t need to spend much time with adolescents before you realise that celebrities are more important to them than their physics teacher.’ Similarly, concluding that parents without STEM educations do not inspire choices of STEM would also be obvious: ‘Not matter how well they know you, how could anyone without any insight into STEM inspire a choice of mathematics?’ Both these facts are contradicted by the results in this thesis, yet they could easily be explained by common sense and deemed ‘obvious’. Challenging strong beliefs is, thus, a legitimate research pursuit.

In the following sections, parents (Section 5.3), teachers (Section 5.4) and celebrities (Section 5.5) are discussed separately. Implications of these discussions are given in Section 5.8.
5.3. All ways lead to Home: The influence of parents

Parents’ influence on educational choices

When Norwegian students elaborate on their educational choices, their stories often lead home – home to the parents talking around the kitchen table, playing in the garden, and exploring nature on vacations. Perhaps the most obvious effect is due to role modelling: Norwegian youth tend to choose educations in similar branches as their parents. According to the results presented in Article I, about every second Lily respondent has at least one parent with a background in STEM, and these respondents claim to be more inspired by parents than do other respondents. Moreover, when parents are described in the open-ended questions, the most frequent examples are of parents ‘modelling a self’; they are role models with STEM occupations themselves. Notably, parents’ role model effect is conditioned. Drawing on data from high-school students in Switzerland, Wiese and Freund (2011) state that ‘parents served as a role model if their actual behaviour as reported by the adolescents converged with what these adolescents wished for during their childhood’ (p. 223). Indeed, parents’ behaviours are of crucial importance for attitudes and career plans, Wiese and Freund claim, but cognitive-evaluative processes are taken into account together with modelling. This reflected modelling might be part of why research on the influence of family on career choices is complex and inconclusive.

Through the many descriptions of parents influencing educational choices, the Lily respondents shed light on some of the ways parents – regardless of their background – might inspire academic effort. Three of these will be mentioned here. Firstly, it is evident that many students have discussed their educational choice with their parents. The number of parents without STEM educations attributed with ‘inspiration or motivation’ for the educational choices of STEM students indicates that something besides classical role modelling takes place in some homes. And indeed, they write so in the open-ended questions. Conversations with parents have helped them get to know themselves and believe in their abilities. Many mothers are mentioned in this respect. Similar results were found in the Futuretrack study (Purcell et al., 2008), where higher education choices among UK applicants in 2006 were investigated. More than 80% of the respondents either strongly agreed or agreed to the statement, ‘My family were [sic] very supportive in my choice of course’. Also the students whose parents did not have higher education claimed this.
Secondly, several respondents describe how their parents held expectations of them. Symbolic interactionism elaborates on how people are affected, to a varying extent, by what others expect of them. Robert Merton’s (1948) ‘self-fulfilling prophecies’ apply here: if significant persons expect someone to choose a particular education, it might happen – partly due to these expectations. Parents, who stand in close interpersonal relationships with adolescents, are particularly influential. This is due to the fact that in such relationships ‘there is substantial and ongoing opportunity to be exposed to those expectations’ (Aron, 2003, p. 444). In his work concerning significant persons, Woelfel explored the relationship between parents’ expectations and adolescents’ occupational aspirations, and concluded that these ‘were very well predicted by the average expectations of their significant others’ (Woelfel & Evans, 2008, p. 2). Notably, expectations might turn into pressure. Some Lily respondents used words like being ‘pushed’ and ‘pressured’, and some Futuretrack respondents also reported how family pressure had constrained their choices (Purcell et al., 2008).

Thirdly, parents’ behaviours – including vacation plans, purchases, feedback and subtle gestures – communicate which activities are valued and which are not. Many Lily respondents appreciated popular science at home through magazines and TV, they spent their vacations exploring nature, and they were encouraged to take part in tinkering with cars and constructing cabins. Feedback on academic achievements, perhaps in terms of a smile, has encouraged some girls and boys in their pursuit of STEM and led some to attach pride to STEM achievements. The climate for children’s motivation development is set by parents’ behaviours, in that parents provide activities and resources that might stimulate them to engage in certain activities over time (Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2007). Conclusively, parents often deeply influence the values of their children. For instance, a parent whose memories of mathematics from school are mostly negative might conclude that ‘mathematics was not for me’. This influences how the parent interacts with the daughter or son with regard to mathematics; perhaps by communicating the idea that this particular subject is okay to give up on, that this subject only suits certain kinds of people, or that ‘we’re not cut out for this in our family’. In contrast, through taking an interest in their mathematics homework and their life at school, parents communicate the importance of mathematics and education. Among others, Smith and Hausafus (1998) point to how this involvement ‘may help early adolescents to see themselves as practicing scientists’ (p. 123). Moreover, Wigfield and colleagues (2007) argue that the culture the family belongs to and
the social roles the children learn, directly influence their values. Included in these social roles might be, for instance, relationship to school activities and attitudes towards STEM.

**Overcoming social background**

It is exemplified in the discussion above that through conversation and support, through holding academic expectations and through valuing certain activities, the Lily respondents’ parents have influenced their educational choices. A student’s background and home environment is a strong predictor of the student’s choices and achievements in school. Describing issues of equity in learning opportunities and outcomes, OECD published some results from the 2009 PISA survey under the title *Overcoming Social Background* (OECD, 2011). The occupational reproduction found in Norway indicates that social background not only applies to learning, but also to educational choices. Most science education researchers are highly aware of the importance of socio-economic status (SES) on most aspects related to educational priorities, and many have pointed to reasons for this. Contributing factors include family structure, financial resources and parents’ education and occupation. For instance, parents’ education has been shown to influence academic expectations (Davis-Kean, 2005), the amount of literacy activities in the home (Kohl, Lengua, & McMahon, 2000) and the collaboration with teachers (Hill & Taylor, 2004).

SES is operationalised through measures such as income, years of education and number of books in the home (see e.g., OECD, 2011). These are proxies related to fundamental patterns embedded in the home and in the family culture, including issues of language and literacy, awareness of health and nutrition, the learning environment at home, daily routines and general parent-child interactions (Levin & Belfield, 2002). For instance, asking parents to follow up homework presupposes routines in everyday life. Many of these issues are encompassed in Coleman’s (1988) notions of human and social capital. The human capital refers to skills and capabilities, while social capital refers to the resources in a social network that foster support and guidance: ‘Social capital within the family that gives the child access to the adult’s human capital depends both on the physical presence of adults in the family and on the attention given by the adults to the child’ (ibid., p. 111). For parents with little human capital in terms of STEM knowledge, social capital still plays an important role. The social capital facilitates attitudes and choices through a social environment that holds expectations, creates obligations, ensures necessary psychological support and increases the number of information channels. Related to this is also Bourdieu’s notion of
cultural capital (e.g., Bourdieu, 1997). The attitudes, habits and priorities of parents, Bourdieu claims, are transmitted to children. This reproduces the dominant culture, influencing how children relate to and succeed in the educational system. Adamuti-Trache and Andres (2008) discuss how cultural capital influences the extent to which adolescents embark on and persist in scientific fields of study. The clear reproducional pattern makes them call for further research on ‘how educated parents influence their children’s academic choices and, in doing so, the ways in which they push their children towards more science-oriented course work’ (ibid., p. 1576).

Notably, the notions of social and cultural capital sheds light on an apparent paradox; the contrast between sociologists’ descriptions of our time, where detraditionalisation has taken place (Beck et al., 1994) and personal satisfaction is prioritised when career decisions are made (Inglehart, 1997), and the statistical fact that students’ priorities and success in the educational system to a great extent are predicted by parents’ education (e.g., Adamuti-Trache & Andres, 2008; Jacobs & Bleeker, 2004). Both these contrasting tendencies are exemplified in the Lily study: most students describe that they were free to choose educations leading towards ‘something I am interested in’. Yet, numerous examples have been provided throughout this thesis of ways that parents’ backgrounds play important roles in choice processes. This might, thus, not be a paradox after all. Cultural capital is transmitted from parents to children, strongly shaping children’s interests and values, leading them to freely create educational patterns that are similar to parents’ patterns.

Returning to the term ‘overcoming social background’, this thesis explores how parents – regardless of social background – can inspire educational choices. In this section, three ways that parents have influenced Lily respondents’ educational choices have been described. Parents from homes with low socio-economic status can also take part in this; encouraging children, holding academic expectations and engaging in free and accessible STEM-related activities. Convincing parents about the importance of STEM is the first step in convincing children about the same. This might provide many girls and boys from low-SES homes with new opportunities in terms of educational choices.
5.4. Teachers inspire STEM choices

When asked about their relationship to mathematics, many persons often start talking about a mathematics teacher. This teacher either inspired them or removed all interest. A major result in this thesis is the acknowledgement of good science and mathematics teachers. Among the 5007 STEM students in the Lily project, almost 400 include a teacher when describing their educational choice. That is; hundreds of students actively chose to write about one or several of their science and mathematics teachers in open-ended questions, indicating that there are many inspiring teachers in Norway. Individual teachers in science, mathematics, physics, chemistry and biology, spread out in primary, lower secondary and upper secondary schools have inspired future STEM practitioners.

Several ways that teachers have inspired choices of STEM educations are described in Article I. To a great extent, the Lily respondents’ stories about their teachers revolve around their teachers’ enthusiasm. Many responses indicate that teacher enthusiasm is contagious. Alongside with this, teachers are described highly flattering. In about 50 % of the stories about teachers, adjectives like ‘clever’, ‘inspiring’ and ‘brilliant’ accompany the mentioning of the teacher. Conclusively, the Lily respondents tell stories about teachers who are positive role models. These role models have provided examples of persons who relate strongly to science and mathematics. They are dedicated and hold a high level of engagement.

In order to display such enthusiasm, teachers need to be confident in the subjects. Osborne, Simon, and Collins (2003) suggest that the high number of teachers who teach subjects outside their specialisation explain why certain subjects are less liked by the students. They highlight physics as an example, and hypothesise that unengaging and didactic modes of teaching is a common escape for teachers who are unconfident and lack familiarity with the subject. The Lily respondents’ stories thus point to the importance of well-targeted teacher recruitment in order to raise engagement in the classroom. Recruitment of future STEM practitioners depends on recruitment of science and mathematics teachers who know the subjects well.

Notably, signs of a negative development have been present in Norway in the last decades. Reports point to the lack of competent teachers in science and mathematics, and the enrolment in teacher training is insufficient (Norwegian Ministry of Education and
Research, 2009). Few students in upper secondary want to become teachers (Bøe, 2012), and neither do many STEM educated persons with pedagogical training (Næss, 2002). These figures might indicate that being a teacher is not regarded as a high-status job in Norway. This gives reason for concern about the teacher status in general, and the recruitment of future science and mathematics teachers in particular. If being a teacher is considered attractive, it is easier to convince persons who are enthusiastic about science and mathematics to become teachers. It is outside the scope of this thesis to provide a full discussion on how teacher status might be raised, but probably, it will have to take sustained effort from different stakeholders. Either way; the message in this thesis is that high teacher status in society has great benefits, not only with regard to the general upbringing of knowledgeable citizens in a democratic society, but also with regard to participation in STEM.

Another feature that Lily respondents highlight about their teachers is related to encouragement. Two factors make encouragement from teachers particularly important. Firstly, they have credibility in terms of content knowledge. When a specialist honestly claims that something is well done, the statement appears reliable. Secondly, they have credibility in that they might know the students well. Most often, teachers get to meet students weekly for at least a year. Depending on factors such as the number of students in class, number of lectures during a week and teachers’ general work load, teachers have the opportunity to develop sound and meaningful interpersonal relationships. Combined, these two factors contribute to assigning great value to the encouraging words of a trusted teacher. Respondents in project Lily provide examples of the potential impact of a short sentence told by the right person in the right moment. Teachers have helped students identify own interests, they have suggested educations and careers, and they have made girls and boys realise their own potential. The two latter points are strongly related to Eccles and colleagues’ (1983) concept of ‘expectation of success’, which according to their model is directly related to educational choice. A credible teacher suggesting that a person might pursue an education increases this person’s belief in own proficiency: ‘This is something I can do’.

This point is particularly important with respect to girls. In many studies, girls tend to report lower self-efficacy in STEM than do boys (e.g., Preckel, Goetz, Pekrun, & Kleine, 2008; Simpkins, Davis-Kean, & Eccles, 2006). Moreover, Article I highlights that women more
often attribute teachers with influence for their choice of STEM, and according to Zeldin, Britner, and Pajares (2008) women build self-efficacy drawing on interaction with other persons more than do men. Thus, significant persons have a particular opportunity to help girls gain a realistic view of own opportunities. In many cases, this will mean to heighten their expectation of success, which increases the possibility of a choice of STEM education.

Osborne, Simon and Collins (2003) state that with respect to school, teacher variables ‘are the most significant factor determining attitude’ (p. 1070). Moreover, results from project Lily suggest that teachers are highly influential with respect to attitudes and participation.

The evident importance of teachers might be explained drawing on how Woelfel and Haller conceptualise significant persons. They define four ways to exert attitude influence. Teachers are in a particular position in that they have the possibility to exert all four modes of influence: They have competence to talk about STEM and to provide experiences within science and mathematics (defining and modelling STEM, respectively), their engagement in the subjects provides students with role models (modelling a self), and their interpersonal relationships with students provide opportunities to encourage adolescents and to help them get to know their abilities and opportunities (defining the self). Combining the fourfold of significant person influence this way, makes teachers – alongside with parents – the most important key players in the effort to increase young people’s participation in STEM.
5.5. Significant persons in various media

STEM celebrities

According to Article I, about 95% of the responses to the closed question regarding inspiration from publicly known persons were in the lower two categories. The responses to the open-ended questions in project Lily include only 85 references to celebrities – about one description for every 60th respondent. The majority of descriptions concern international TV celebrities like MacGyver (six references), David Attenborough (six references) and Steve Irwin (four references). These three persons are, together with Norwegian astronomer Knut J. R. Ødegaard (five references), the only celebrities mentioned more than three times. Norwegian STEM celebrities are only described 14 times, Ødegaard included, and historical scientists like Einstein and Newton are described only ten times. Conclusively, publicly known persons in the media are credited with a notably small influence on STEM educational choices by the Lily respondents.

There might be several reasons why respondents did not report more inspiration from publicly known persons, besides the direct interpretation that celebrities have a small impact. Some might be uncomfortable attributing celebrities with important influence, some might not have realised that they are in fact influenced by these persons, some might actually acknowledge this influence but did not choose to write about it, and so forth. Two possibilities are of particular interest: (1) Norwegian youth are simply not influenced by publicly known people in the media, and (2) we have too few inspirational STEM celebrities present in the Norwegian media picture. The first possibility might have something to it. Norwegian youth are experienced media consumers, and they might have braced themselves against this influence. However, results from project Lily indicate that media matters. The difference between student groups’ responses to the closed question about inspirational films and TV series support the claim of a positive ‘CSI effect’ (Schreiner et al., 2010). CSI is a TV series where biotechnology is applied in criminal investigations, and this was stated as an example of a TV series in the question (Appendix 1, Question 21 i). More than 50% of the bioengineering students responded in the top two categories to this item, while only 18% of the other respondents did the same. Moreover, CSI was mentioned 23 times in the open-ended questions. The bioengineering students, constituting only 4% of the respondents, wrote 15 of these 23, reinforcing the idea of a positive CSI effect. Notably, outside Norway,
the ‘CSI effect’ often refers to negative aspects. These include jurors holding unrealistic expectations of scientific proofs in courtrooms and students being provided with unrealistic views of scientific methodology (Bergslien, 2006).

Another striking example of media influence is the Norwegian weather forecaster Siri Kalvig. Up until 1992, meteorology studies were heavily dominated by men and the weather forecasters on the leading national TV station were all men. Siri Kalvig entered the stage as a female weather forecaster in 1992. Throughout the following two decades, Kalvig has had frequent exposure in different media, both with respect to environmental issues and as a successful founder. Similarly, the majority of meteorology students in Norway has shifted from men to women (Sæthre, 2005). It is commonly claimed that Kalvig, together with the female colleagues who followed in her footsteps, caused a shift in the public image of meteorologists in Norway. As indicated by the results of this thesis, female meteorology students will probably not claim that ‘I want to be like Siri Kalvig’. More likely, the increased participation of women in this subject is due to the new values associated with it. Through media exposure, Kalvig and her colleagues have convinced adolescents that femininity and environmental engagement might be parts of a ‘meteorologist role’.

Thus, even though it is repeated throughout this thesis that those who know adolescents personally are particularly important, the conclusion here is not that persons in the media are irrelevant. Explanation 1 suggesting that persons in the media do not influence adolescents is, at best, only partially true. The second explanation, concerning lack of STEM celebrities in the media, seems more likely. Among the 50 professors that appear most frequently in the Norwegian media, only a handful represent the STEM subjects (Ballo, 2008). Moreover, Vikebak (2009) analysed the presentation of scientists in Norwegian media, and he concluded that journalists draw an unclear picture of STEM people (Vikebak, 2009). This might partly explain why few STEM celebrities are described by the respondents as influential on their educational choices. If a role is not clearly presented, the role model effect is restricted (McClelland, 1951). As a consequence, young people are left with the stereotypical images of STEM persons. These are, according to science education research on ‘images of scientists’, incomplete and partly negatively loaded (Cakmakci et al., 2011).

Increasing the exposure of STEM practitioners in the Norwegian media is no straightforward matter. A panel debate held by the Department of Physics and Technology at the
University in Bergen, Norway, was entitled *Do you have to be a clown to get attention in the media?* (University of Bergen, 2008). The title points to a challenge for researchers who want to communicate the important, fun and exciting aspects of STEM subjects. On one hand, researchers need to be sufficiently precise and include relevant reservations. This is not easily compatible with many of the modern media formats. There is a pendulum swinging between being thorough, precise and objective on one side, and being simplistic but entertaining on the other side. The panel debate title suggests that the pendulum has swung towards the latter. Managing both aspects at the same time – being informative and entertaining – is possible, but some STEM subjects are perhaps particularly difficult to communicate in this way.

**Historical STEM practitioners: A note on school textbooks**

The school science and mathematics textbooks have a great impact on young people’s conceptions of these subjects. Textbooks often include stories about the historical persons who took the fields’ first steps. With regard to inspiration and motivation, however, the STEM respondents in project Lily did not write frequently about Einstein, Newton or Curie. The few STEM celebrities they describe are typically *contemporary* scientists and science communicators (e.g., physicist Steven Hawking, software programmer Linus Torvalds and life scientist David Attenborough). In fact, no STEM celebrity is mentioned more often than MacGyver; a TV series character who uses chemistry, physics and a pocketknife to overcome exciting challenges. In reviewing STEM attitude research, Osborne, Simon and Collins (2003) conclude that most studies point to a gap between general science attitudes and school science attitudes, where the former tend to be more positive than the latter. Thus, the selection of STEM practitioners in school science and mathematics textbooks might, unfortunately, contribute to keeping these two worlds separate.
5.6. Who do I want to be?

The white rubber boots

A picture was shown at a seminar addressing recruitment to the fishing industry in Norway a few years ago (personal communication, Schreiner, 2009). The picture, displaying a female fisher at work, caused a minor disturbance and mumbling in the audience. Was it due to the fact that a woman would work as a fisherman? No. The disturbance was due to a detail noticed by the fishermen in the audience: she wore white rubber boots. Never before had they seen something as silly as white rubber boots on a fishing boat. Dark green, marine blue or yellow boots are what typically accompany someone expressing a fisherman identity. Her boldness exemplifies the necessity many young persons have for tailoring a new and unique role if they are to join the STEM workforce. Among the major results from project Lily is the importance of interest, personal meaning and identity when young persons choose to pursue an education (Schreiner et al., 2010). If the education or career under consideration does not contain predefined and suitable roles for the students to go into, they must tailor a new role – a role that is ‘right for me’ (Schreiner, 2006). This might take creativity, boldness, and in certain instances a pair of white rubber boots.

In line with the above paragraph, sociologists have proposed that the classic question of what you want to be when you grow up, is now more a matter of who you want to be when you grow up (Illeris et al., 2002). Thus, working towards increased participation in STEM is to a great extent about helping young people envision themselves as future STEM practitioners (Lyons & Quinn, 2010). Individuals draw on different experiences and insights to create such ‘possible selves’ (Markus & Nurius, 1986). Some of these experiences and insights will be explored here. It is suggested in Article III that attitudes towards and participation in STEM might be discussed drawing on an introspection-extrospection duality. Thus, the following discussion will be structured according to this, starting with significant persons’ role in adolescents’ extrospective activity: Which careers are out there, and which values do the STEM subjects promote? Following this, some ways that significant persons might influence adolescents’ introspective activity will be discussed: Am I able to go through with this? Am I interested? Young people need to answer such questions in order to evaluate whether or not participation in STEM might be part of ‘who I want to be’.
Significant persons providing information

Whenever teenagers talk about becoming fashion designers and soccer players, this is not necessarily signs of naivety. This might simply reflect the careers they know about. In addition to knowing what their parents do, a primary source of career information is the popular media, where STEM practitioners are underrepresented (Ballo, 2008). This might partly explain why Norwegian teenagers have limited knowledge about STEM educations and careers. According to market analysis institute Synovate, about 60% of Norwegian teenagers know ‘little or nothing about what engineers do’ (Dahle, 2007, my translation) and about 30% ‘do not know what jobs they can get with studies like mathematics, science and technology’ (Pham, 2008, my translation). There is reason to believe that the situation is similar in other Western countries. For instance, in developing a career platform for girls aged 12 to 16, Zauchner, Siebenhandl and Wagner (2007) identified a strong need for information about educational pathways for ICT, engineering and scientific professions. Considering the importance of educational choice, this gives reason for concern. It takes too much time and effort to gain knowledge about educations and careers through trial and error. Adolescents themselves want more career information (Purcell et al., 2008). The recruitment initiative investigated by Cantrell and Ewing-Taylor (2009) illustrates an efficient way to provide young people with such information. Students were invited to weekly sessions where STEM practitioners presented their careers, and the students got to interact informally with them in a following social hour.

Educational institutions, STEM based industry, and policy makers might spend time and money developing information campaigns. However, it is challenging to make these well-targeted: the young persons in project Lily and the ENT3R project highlight a variety of factors as influencing their attitudes towards STEM and choice of STEM educations. For instance, an information campaign emphasising the opportunities to work abroad would probably only appeal to a few. Moreover, young people, well accustomed to the media culture, might be suspicious about the information provided by commercials and campaigns, where information occasionally turns out to be exaggerations or half-truths. Persons in interpersonal relationships with young persons, on the other hand, are more likely to know what the individual girl or boy wants to know, and they also have a credibility advantage over advertisers. Kopp, Hulleman, Harackiewicz and Rozek (2012) describe the positive
effect of providing parents with information about the importance of STEM and guidance on how to have conversations with adolescents about educational choice. Over 15 months, parents of 10th to 11th grade students received two brochures and were invited to visit a website containing such information. The effect of this intervention was indicated by the children’s enrolment patterns. They chose significantly more science and mathematics courses in 12th and 13th grade compared to the students in the control group. Having parents inform adolescents about STEM educations and careers thus seems like an efficient way to increase participation in STEM.

**Significant persons influencing which values are associated with STEM**

Most likely, the values individuals associate with STEM are to some extent inferred from the values they perceive that the persons they include in the ‘STEM people’ group promote through STEM activity. This might be exemplified by three different groups of significant persons. Firstly, not many persons are included in the ‘meteorology group’. Thus, a weather forecaster like Siri Kalvig, presented in Section 5.5, is heavily weighted. She has frequently promoted environmental responsibility through her profession. The result is a clear-cut image of meteorology as an ‘environmental subject’, which seems to suit Norwegian girls well. Secondly, the image of persons included in the ‘mathematics group’ might be more diverse and includes, probably, some teachers. In the final years of compulsory mathematics in school, the students have teachers who are committed to a curriculum in a subject that is perceived as difficult, and where fun and engaging real-world applications might be challenging to include in the teaching. It might be hard for teachers to display who they are and which values might be promoted through mathematics activities. Thus, young persons might be left with the impression of mathematicians as ‘boring’ and the subject as ‘technical and value neutral’, which might constitute a challenge with regard to recruitment to mathematics educations. Finally, the ‘engineering group’ might for some be an empty collection. Without anyone to provide an image of ‘engineers and what they are occupied with’, it is less likely that young persons want to pursue engineering educations.

**Introspection: Identifying own abilities and interests**

Young persons’ choices throughout the education system might to some extent reflect how they perceive themselves and how they would like to be perceived. Taking part in their educational choice processes is thus taking part in their self-development. Holmegaard, Ulriksen and Madsen (2012) describe how young people directly and indirectly share the
story about an educational choice to people they know, seeking feedback on whether it suits them. Their self-development is thus partly contingent on significant persons’ reactions to these stories, leading to the confirmation, revising or rejection of certain choices. The results presented in this thesis suggest that feedback from significant persons is important for students’ self-perceptions with regard to abilities. For instance, as presented in Article II, the ENT3R participants shared stories about how the mentors believed in them and that this in turn made them believe that they have what it takes to succeed. Moreover, symbolic interactionism points to how others’ perceptions of an individual affect how they interact with that person, thus influencing how the individual perceives himself. Young people’s self-beliefs and expectations of success are, among other things, influenced by parents’ perceptions of their competencies, and many different cues might transmit these perceptions. For instance, feedback on achievements transmits ability perceptions. Feedback indicating that an achievement is due to luck or hard work probably does not build self-efficacy as efficiently as attributing it to skills. Exemplifying this point, Jacobs and Eccles (1992) claimed that gender role stereotypes made mothers underestimate their daughters’ mathematics abilities. They were more likely to give feedback attributing achievements to hard work and not skills. Jacobs and Eccles concluded that mothers’ beliefs about their daughters influenced their daughters’ beliefs about their mathematics skills. Thus, the significant persons’ beliefs about the youngsters’ abilities are crucial.

Interests, identified through inspection, are also influenced by significant persons. For instance, Jacobs and Eccles (2000) suggest that how time is spent with adolescents on different academic activities influences their interests and educational aspirations. To some extent, parents and teachers manage much of adolescents’ time, choose activities and provide material resources that support certain interests. A well-known example that relates to STEM concerns what kind of toys girls and boys are given, where technical toys are assumed to stimulate technical interest. Moreover, Article I and Article II both point to different ways that parents, teachers and STEM students have created and stimulated interest for different STEM educations and careers. Conclusively, both ability and interest perceptions might be influenced by significant persons, contributing in various ways to adolescents’ possible selves (Markus & Nurius, 1986); their hopes, fears, fantasies and goals.
Uniting introspection and extrospection

The insight gained through introspection and extrospection might strongly depend on the effort of significant persons. These persons help adolescents learn about themselves and their experiences, about STEM educations, careers and practitioners. The results of these two processes are united when STEM educations are considered. Does this education fit who I want to be? Kessels, Hannover and Taconis elaborate on young persons’ self-to-prototype matching (e.g., Hannover & Kessels, 2002; Kessels, 2005; Taconis & Kessels, 2009). In this matching process, adolescents compare themselves to real or imagined persons they perceive as prototypical for different subjects and careers. Closeness to STEM prototypes increases the possibility of participation in STEM. Kessels and colleagues’ results indicate that the prototypical science student is described by peers in less flattering ways than are other students. Moreover, the students’ self-reports are more similar to how they describe the non-STEM students. This is suggested as part of the reason why many students choose not to pursue STEM; they conclude that they do not match the prototype.

 Returning to the woman with the white rubber boots, young persons either have to find a role in the STEM professions that fits who they are, or they have to gain the courage to create a new role. Either way, the identity matching process might be supported by a parent, a teacher, or, in the case of one of the Lily respondents, a cartoon character: ‘Saw the cartoon *Dexter’s Laboratory* and, kind of, saw myself. Annoying little sister, likes to invent stuff’. A cartoon character helped this girl envision herself as a STEM practitioner. Similarly, many significant persons might support adolescents in exploring who they want to be in a STEM profession.
5.7. Limitations and suggestions for future research

The importance of significant persons for adolescents’ attitudes and educational choices is explored in this thesis. However, this thesis has many limitations and covers only a small part of potentially fruitful research on significant person influence. The results presented here are assumed to vary between educational fields, over time and from culture to culture. Limitations in terms of target groups, research methods and research focus suggest continued research on this matter. Thus, the limitations of this thesis are translated into suggestions for future research.

Other significant persons and potential target groups

With regard to significant persons, some interesting groups did not receive attention in this thesis. Firstly, peers were not specifically investigated. Educational choices are made during a period of life when friends are considered to be highly important. Even though the statement ‘My friends influenced my choice(s)’ received least agreement among the ten items reported in the Futuretrack study (Purcell et al., 2008), there is reason to believe that peers are still highly significant. The Lily respondents credit friends with some degree of inspiration and motivation. The ENT3R respondents also highlight the social aspects with peers in the mathematics mentoring project. Moreover, the subculture developed in peer groups might strongly influence attitudes towards education in general and STEM subjects in particular. Investigating friends as significant persons will provide useful knowledge for persons interested in participation in STEM.

Another group of significant persons that might receive attention in future research is student counsellors. The results from project Lily concerning this group were discouraging. In the closed questions, less than 5% of the STEM respondents claimed that a student counsellor had inspired their educational choice to a ‘great extent’ (Schreiner et al., 2010), and only 30 out of 5007 STEM students mentioned these significant persons in open-ended questions. Examples of successful and well-functioning school counselling do exist, as exemplified by Hipkins, Roberts, Bolstad and Ferral (2006). They concluded that the school career counselling was a success ‘where there had obviously been a sustained effort to build and maintain personal relationships between careers staff and students’ (ibid., p. 53), a conclusion which is in line with the general message of this thesis. Notably, the formal counsellor educations throughout Europe vary greatly. In some countries, school counsellors
often have three- or five-year educations (OECD, 2004), whereas in Norway, ‘a great majority of the school counsellors have little or no formal education in this area’ (Buland & Mathiesen, 2008, p. 33, my translation). This indicates a great potential for improvement. Future research on these significant persons could strengthen the role of school counselling in adolescents’ educational choice.

The target groups in this thesis were the 15- to 19-year-old participants in a mathematics mentoring project and freshmen in tertiary educations. However, research indicates that attitudes towards STEM are quite stable from the age of 14 (Osborne & Dillon, 2008). For instance, drawing on longitudinal data, Tai, Qi Liu, Maltese and Fan (2006) conclude that the 13-year-olds who expected careers within science were more than three times more likely than other children to gain a physical science or engineering degree by the age of 25. Thus, it is suggested here that future investigations might include younger target groups.

The influence of significant persons on girls and boys in kindergarten, primary school and lower secondary school might turn out to be fruitful with regard to participation in STEM in upper secondary and tertiary education.

Moreover, the target groups in this study only included persons assumed to have positive attitudes towards STEM, considering that they voluntarily participated in the mathematics mentoring project ENT3R or that they were tertiary STEM students. Knowledge about the role of significant persons in the educational choice processes of those who are disinterested in STEM and of those who opt out of these subjects would provide interesting supplements to the research presented here. For instance, this could be investigated by allowing former participants in ENT3R to share their experiences. These students decided to quit, and this might very well be related to mentors. More generally, it would be interesting to let adolescents who show no interest in STEM talk about the persons they associate with these subjects. Woelfel and Haller’s framework for investigating significant persons’ influence on attitudes could be relevant in this respect. The lack of interest could be related to the lack of role models, because no one has provided relevant information or experiences, or because no one has made them believe that they are able to succeed in STEM. Specifically, the investigation of significant person influence on those who do not want to engage in STEM would be relevant in addressing the question about causality. It is documented here that significant persons are part of educational choice processes and that they have, indeed, inspired STEM choices. However, this thesis does not explore the reversed causality: STEM
choices might lead adolescents to (subconsciously) identify significant persons. For instance, it would be reasonable to expect increased attention to certain role models after a specific educational choice has been made. Insight into the significant person identification process would be an interesting development of the present research.

**Suggested research methods**

Time, resources and practical constraints limited the selection of research methods in this thesis. Other research designs are suggested here to deepen the understanding of significant person influence. For instance, the Lily questionnaire utilised in this thesis contains relatively few questions about significant persons. As the SPIAS instrument developed here investigates the ways that a significant person influences attitudes towards STEM, a more extensive questionnaire might be developed for studying who plays the different roles in the educational choice process. For instance, only one question regarding the influence of persons in the media was included in the Lily questionnaire. As discussed in this thesis, data indicate that celebrities' influence has more impact than what the responses to this single item would suggest. An extended questionnaire could treat this issue more thoroughly, investigating the processes of how persons in the media influence educational patterns and the public image of STEM.

Moreover, as the development of attitudes towards STEM and the educational choice processes continue over years, longitudinal research designs might provide valuable insight. Correlations between significant persons’ behaviour and adolescents’ educational choices could be explored. For instance, parent-child interaction studies might focus on the development of attitudes towards STEM. By linking such studies with theoretical perspectives on social capital, cultural capital, or other issues related to social background, valuable knowledge about important challenges in society might be produced.

The Significant Person Influence on Attitudes towards STEM (SPIAS) questionnaire has been developed in this thesis. The instrument is both empirically and theoretically robust, and it is suggested that SPIAS is applied to investigate efforts initiated to increase participation in STEM. The instrument was validated in a specific context – a Norwegian mathematics mentoring project – but might be applied, revised and validated for use in other contexts. For instance, the instrument is highly relevant for longitudinal research where attitude change is investigated.
A major limitation of this thesis, and true for many of the research methods suggested above, is that it depends on self-reports, and thus it relies on respondents’ self-knowledge, memory and honesty. Investigating significant person influence without using self-reports might be done, for instance, through observation studies. This might provide an important supplement to the research conducted in this thesis.

The retention challenge

Finally, with regard to the number of STEM practitioners needed in the workforce, increased participation in STEM educations is the first of several steps. Only about 60% of the Norwegian engineering students complete their education (Statistics Norway, 2011), indicating that retention is a major challenge. In countries within the Organisation for Economic Co-operation and Development (OECD), about 30% of the students enrolled in tertiary programmes leave without a tertiary degree (OECD, 2009a). Keeping students from dropping or opting out of STEM educations would greatly contribute to diminishing the recruitment challenge. Having reviewed research on retention in STEM, Ulriksen, Madsen and Holmegaard (2010) suggest that further research might investigate ‘the issue of identity construction and of being recognised as a legitimate member of the group of science people’ (p. 238). This might be addressed by exploring how significant persons – for instance fellow students and university employees – influence students’ conceptions of themselves and their conceptions of prototypical science students and practitioners.
5.8. Implications

Including parents in efforts to increase participation in STEM

The Lily respondents provide ideas for how recruitment campaigns might involve or be targeted at parents. Drawing on the results in this thesis and theoretical considerations, it is suggested that parents’ priorities and what they do when they spend time with adolescents, communicate the value of different activities. Thus, grown-ups who provide adolescents with STEM experiences, for instance through spending time reading popular science literature, and who take an interest in their mathematics and science homework, communicate the importance of education in general and STEM in particular. Parents can be invited to take part in STEM activities together with their children, like museum visits arranged by the school. They can be invited to free courses, like the courses in Norway designed to help parents to assist their children with mathematics homework (Norwegian Agency for Lifelong Learning, 2012). Generally, providing parents with new and positive experiences with science and mathematics might influence how their children perceive these subjects.

Throughout this thesis, adolescents express the need for more information about STEM educations and careers. Parents do not necessarily know much about the development in STEM and the role of STEM-related careers in the future. Parents might be provided with information about the career opportunities in STEM, as they have the opportunity to target the information flow to the particular girl or boy, and as they might be considered as trustworthy informants. Convincing parents that STEM careers are secure, well-paid, possibly exciting and fun, and suitable for persons with many different interests, values and priorities, might inspire them to encourage and support STEM choices. In particular, convincing parents that STEM educations are also possible for those without exceptional talents is important, as the results of this thesis suggest that parents’ perceptions of their children’s abilities influence the children’s self-perceptions. Notably, respondents in project Lily shared different experiences related to parents’ well-meant expectations, and parents might be made aware of the potential positive and negative influences their expectations might have.

Many of these implications do not exclude parents in homes with low socio-economic status (SES). Inviting parents to free courses and STEM activities might be considered as part of
the effort to achieve equal educational opportunities for adolescents from different backgrounds in terms of SES. Central components in the SES measures will not be improved by such recruitment initiatives, that is, parents’ educational credits and income will stay the same. However, through recruitment initiatives that last over time and include the parents, other components of sound SES measures, like the social and cultural capital of the family, might increase. The domestic transmission of cultural capital from parents to children, described in various ways in this thesis, is according to Bourdieu ‘the best hidden and socially most determinant educational investment’ (1997, p. 48).

**Supporting science and mathematics teachers**

A general message from this thesis concerns how teachers are discussed both publicly and privately: everyone wants skilled, engaged teachers who connect with students and inspire them. The good news here is the fact that we have many of these teachers in Norway, as evident from the descriptions given by Lily respondents. Norwegian science and mathematics teachers might be encouraged by learning more about the important roles they hold in many of their students’ lives. Convincing teachers about their potential impact on students’ self-views and educational choices might increase their consciousness of the signals they send about the students, the subjects and what kind of persons are suitable for STEM careers. For instance, awareness about feedback on academic achievements is important; feedback should be realistic and attributed to students’ skills whenever reasonable. A continued focus on recruitment of good science and mathematics teachers and professional development for those already in the profession is important and necessary to promote participation in STEM.

Considering the low number of students in engineering and other ‘applied’ STEM educations who claim to be inspired by teachers, science and mathematics teachers might to a greater extent draw on applied STEM subjects in the classroom. Other stakeholders are encouraged to tailor teaching material and activities that target the curriculum and show the applications of STEM to real-world challenges and modern industry. Such material must be easily accessible, directly relevant to curriculum goals, and clearly defined with regard to learning outcomes. The *Norwegian Centre for Science Education* exemplifies how such material might be developed and promoted. Other stakeholders, for instance leading actors in the STEM based industry, might take part in developing teaching material to a greater extent.
While school science textbooks often present historical STEM practitioners, the respondents in project Lily to a greater extent mention contemporary STEM practitioners when describing famous significant persons who inspired their choice. Portraying these in science and mathematics textbooks could strengthen the link between adolescents’ interests and the subjects taught in school. This way, students might see that mathematics and science are important subjects for the activities of the persons they know through popular culture.

**Contributions from the STEM community**

The potential influence exerted by significant persons in the media is exemplified by the positive ‘CSI effect’ identified in project Lily. Participation in STEM will probably increase if STEM practitioners develop a culture where popularisation and media appearances are regular parts of their academic activity. Courses might be offered to give media training, resources might be allocated for efforts to communicate research results, and science communication might be credited alongside student credit production and publication of articles. Many STEM careers are unknown to adolescents, and the breadth of STEM practitioners is not present in the media picture. The STEM community is encouraged to continue looking for new ways to promote role models through different media formats.

The power of the personal meeting is pointed to throughout this thesis. Those who are present at different events, like workplace visits or career days in school, are encouraged to prioritise personal interaction; meeting girls and boys personally, showing interest in them, and talking warmly about their everyday life in a particular company or in the STEM industry. For instance, when school classes are on workplace visits, the results in this thesis suggest that the students might be given the opportunity to meet many different employees, showing them the breadth of roles available to persons who engage in STEM.

The primacy of role accessibility for the educational choice is implicit in many of the results in this thesis. STEM practitioners must be welcoming and open to a wide range of persons in their workplace – including those who hold unconventional ideas, explore different research strategies, and promote other values through their STEM activity. Moreover, they might look for ways to communicate how STEM educations and careers are suitable for a range of persons and personalities.
Conclusively, to help adolescents envision themselves as future STEM practitioners, they need to meet and see real STEM practitioners; significant persons who visit schools, comment on relevant news in the media, arrange public events promoting STEM, hold important roles in TV series, are active on Facebook and appear on YouTube. STEM practitioners and other stakeholders might all be or encourage and promote other significant persons in order to increase participation in STEM.
5.9. Conclusions

Four research questions have been investigated through the work presented in this thesis. Research question 1 concerns significant persons as sources of inspiration for choice of STEM in higher education. This is elaborated on in Article I, where it is documented that significant persons hold important roles for many students. In particular, those the students know personally are emphasised, like parents and teachers. Research question 2 concerns the ways that parents, teachers and other persons in interpersonal relationships with adolescents inspire choices of STEM educations. Article I provides self-reports concerning the influence of parents and teachers on tertiary students’ STEM choices and elaborates on how parents and teachers have defined the students’ selves, defined STEM, and provided examples of STEM and persons who engage in STEM. Article II describes what the participants in the mentoring project ENT3R appreciate about the project, namely the mentors: they provide good teaching, create a positive atmosphere, engage in interpersonal relationships and are positive role models.

The third research question concerns the utility of Woelfel and Haller’s theoretical framework. Article I and Article III exemplify how this framework might be applied to investigate significant person influence. In Article I, it is applied to structure the discussion of parents and teachers as sources of inspiration for choices of STEM in higher education. Moreover, evident from Article III, the framework functions well as a starting point for developing a questionnaire instrument measuring significant person influence on attitudes towards STEM. The second part of Research question 3 concerns the strengths and limitations of Woelfel and Haller’s framework. In Article I, it is concluded that it provides a useful structure for discussing significant person influence. The four constructs are theoretically well defined; a claim that receives support from the development of the instrument in Article III. In line with Nauta and Kokaly’s (2001) proposal, the framework covers not only dimensions related to modelling and exemplifying, but also dimensions related to personal support and guidance. Moreover, the framework nicely emphasises the fact that two components are crucial for attitudes and educational choice: the self-concept and the conception of the educations being considered. Turning to limitations of Woelfel and Haller’s framework, the distinction between the four constructs does not follow intuitively from the names of the constructs. It requires some effort to thoroughly understand these. For instance, when it comes to the concept of teaching, the distinction
between defining and modelling an object might be diffuse. Moreover, the framework is limited in that it does not provide information about the weighting of the different modes of influence; which modes are more important for different persons and different attitudes.

The fourth research question is answered in Article III. Here, the Significant Person Influence on Attitudes towards STEM (SPIAS) instrument is developed drawing on Woelfel and Haller’s framework and Rasch analysis of data collected in a pilot study. The instrument, validated in the context of a Norwegian mentoring project, holds good psychometric properties and measures Woelfel and Haller’s four modes of significant person influence. SPIAS might be applied in similar mentoring projects, or it might be adjusted to and validated in other contexts where persons seek to influence attitudes towards STEM.

Taken together, the effort of pursuing these four research questions has contributed to increasing the understanding of significant persons’ influence on young people’s attitudes towards and choice of educations within science, technology, engineering and mathematics – which was the overall aim of this thesis.

Regarding attitudes towards STEM and choice of STEM educations, the message in this thesis is that parents, relatives, teachers, friends, students, professionals and celebrities are all potential key players in developing these attitudes and promoting STEM educations and careers. In particular, those in interpersonal relationships with young people have ongoing opportunities to exert such influence. Other perspectives on the issue of participation in STEM are also fruitful, like a gender perspective, a purely sociological perspective or a purely psychological perspective. Ultimately, the total effort will be decisive in increasing participation in STEM; the number of stakeholders taking action, the number of arenas where adolescents get experiences with STEM, the quality of recruitment initiatives, the efficiency of incentives, the presentation of science and mathematics in school, the engagement of science and mathematics teachers, and so forth. Significant persons are part of this greater picture, contributing to the total effort to foster positive attitudes towards STEM and increase participation in these subjects.

In concluding this thesis, I want to emphasise the following: All persons in interpersonal relationships with young persons might function as significant persons in an educational choice context. The three articles that follow all point to why this is true.
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ARTICLE I

Title: Sources of inspiration: The role of significant persons in young people’s choice of science in higher education

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Sources of Inspiration: The role of significant persons in young people’s choice of science in higher education

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The objectives of this article were to investigate to which extent and in what ways persons influence students’ choice of science, technology, engineering, and mathematics (STEM) in tertiary education, and to assess the suitability of an analytical framework for describing this influence. In total, 5,007 Norwegian STEM students completed a questionnaire including multiple-choice as well as open-ended questions about sources of inspiration for their educational choice. Using the conceptualisation of significant persons suggested by Woelfel and Haller, the respondents’ descriptions of parents and teachers are presented in order to elaborate on the different ways these significant persons influence a STEM-related educational choice. Parents engaged in STEM themselves are models, making the choice of STEM familiar, and they help youngsters define themselves through conversation and support, thus being definers. Teachers are models by displaying how STEM might bring fulfilment in someone’s life and by giving pupils a positive experience with the subjects. They help young people discover their STEM abilities, thus being definers. Celebrities are reported to have minor influence on STEM-related educational choices. Both qualitative and quantitative analyses indicate that interpersonal relationships are key factors in order to inspire and motivate a choice of STEM education. Implications for recruitment issues and for research on interpersonal influence are discussed. It is suggested that initiatives to increase recruitment to STEM might be aimed at parents and other persons in interpersonal relationships with youth as a target group.

Keywords: Significant persons; Recruitment; Parents

Introduction

‘No man is an island’. John Donne’s classic claim deals with what many researchers have explored and described: How humans depend on each other and influence
each other. Teachers, friends, and celebrities might influence how a young girl or boy thinks of travelling, computers, paragliding, or bananas. The range of interpersonal influence is wide and also attitudes towards science, technology, engineering, and mathematics (STEM) are influenced by other persons.

The development of STEM has been, and will continue to be, decisive for the development of the modern world. Creative innovation and technological progress are important elements to improve the lives of humans and to preserve the environment. Yet reports conclude that there are too few STEM students to meet estimated future demands in OECD countries (OECD, 2008), in the USA (Stine & Matthews, 2009), Australia (Lyons & Quinn, 2010), Europe (EU, 2004), and in Norway in particular (Bjørnstad, Fredriksen, Gjelsvik, & Stølen, 2008). There is a growing concern about young people’s – and particularly young women’s – lack of participation in STEM educations in many Western, modern countries. Attracting a greater and more diverse group of young people to scientific and technological careers might be expected to give a future STEM workforce that is not only greater in numbers and more even in gender distribution, but that generally includes a greater multitude and variety of outlooks, experiences and aims – possibly increasing the innovative potential (Schiebinger, 2008). In addition to securing the society’s need for STEM competence, increased participation in STEM has a literacy and empowerment component: Insight and participation in STEM may enhance democratic processes, bring self-fulfilment, and enrich the lives of those who participate. Thus, recruitment of young people to STEM educations meets not only societal, but also individual needs.

Purpose

The objectives of this article are (i) to investigate to what extent STEM students claim to be inspired or motivated for their educational choice by individuals in general and by parents and teachers in particular, (ii) to describe the different ways parents and teachers influence a STEM-related educational choice, and (iii) to assess the suitability of a theoretical framework for studying the influence of significant persons on STEM-related educational choices. The overall aim is to increase the understanding of how persons may contribute to improve recruitment to STEM-related educations. Questionnaire data from 5,007 Norwegian STEM students in the research project Lily (Schreiner, Henriksen, Sjøastad, Jensen, & Løken, 2010) will be analysed in light of the above objectives. Perspectives from social psychology about significant persons, as described in symbolic interactionism, will serve as a theoretical base. In particular, the conceptualisation of significant persons suggested by Woelfel and Haller (1971) will be utilised to discuss how persons influence an individual’s choice of a STEM-related education.

Background

Attitudes towards STEM have been investigated in different ways during the last decades. Schreiner and Sjøberg (2007) point to the fact that young people in
Western, modern countries value science highly without engaging in science themselves. The decline in positive attitudes towards science from age 11 to age 14 is well documented (Bennett & Hogarth, 2009). Cleaves (2005) found that the secondary school pupils in her research did not see scientists as people they would want to be like. The pupils in the research of Taconis and Kessels (2009) considered the typical peer who favoured science as someone less attractive, less popular, and less socially intelligent than pupils favouring the humanities. In particular, the discrepancy between a female identity and a science identity has received attention (e.g. Brickhouse, Lowery, & Schultz, 2000).

Reviews of STEM attitude research often include articles regarding interpersonal influence (e.g. Osborne, Simon, & Collins, 2003; Osborne, Simon, & Tytler, 2009). In particular, parents and teachers are highlighted as important for young people’s attitudes towards STEM, their willingness to participate in STEM educations, and their persistence in STEM training (e.g. Adamuti-Trache & Andres, 2008; Carrington, Tymms, & Merrell, 2008; Hazari, Sonnert, Sadler, & Shanahan, 2010). Young people’s skills and achievements in STEM are also influenced by other people (e.g. Hazari, Tai, & Sadler, 2007). Interpersonal influence is often investigated with respect to gender (e.g. Gilmartin, Denson, Li, Bryant, & Aschbacher, 2007).

Interpersonal relationships and the support provided through these are of great importance. Nauta and Kokaly (2001) developed a tool to assess how persons influence young people’s academic and vocational decisions. They concluded that in addition to providing inspiration and serving as examples, persons influence academic and vocational choices by providing support and guidance. Many projects aimed at improving pupils’ attitudes towards STEM involve STEM students and STEM professionals (e.g. Bruce, Bruce, Conrad, & Huang, 1997; Evans, Whigham, & Wang, 1995). In the intervention described by Buck, Clark, Leslie-Pelecky, Lu, and Cerda-Lizarra (2008), pupils had a female scientist in class at least one hour per week throughout a year at school. The researchers described a great change in girls’ images of scientists throughout the intervention. They concluded that the interpersonal relationship was the decisive factor. Several other researchers also highlight the importance of interpersonal relationships (e.g. Aschbacher, Li, & Roth, 2010).

Theoretical Perspective

In this article, Woelfel and Haller’s conceptualisation of significant persons will be applied. The tradition from where this term had originated — symbolic interactionism — and the view of self in this tradition will be presented first. This is followed by an elaboration on the four ways in which significant persons influence attitudes as suggested by Woelfel and Haller.

A main idea of symbolic interactionism, led by Charles H. Cooley and George H. Mead, is that we come to know ourselves ‘by observing how we fit into the fabric of social relationships and how others react to us’ (Swann Jr & Bosson, 2010, p. 589). Cooley’s (1902) looking-glass self exemplifies this idea: According to symbolic
interactionism, the inner self starts off nearly empty at birth, but gradually accumulates as ‘parents, teachers, peers, and others inform the child about itself’ (Baumeister, 1999, p. 10). The self-concept is manifold and represented in various ways in the individual. Higgins (1987) proposes three different domains of the self: The actual self (attributes you believe you possess), the ideal self (attributes you would like to possess), and the ought self (attributes you should possess). Swann Jr and Bosson (2010) make a distinction between global self-views and specific self-views. The former concerns an individual’s main characteristics and general knowledge about the self, while the latter concerns specific skills and abilities. Moreover, Aron, Aron, Tudor, and Nelson (2004) describe how close relationships can lead to overlapping self-concepts: ‘The principle is that in a close relationship, the person acts as if some or all aspects of the partner are partially the person’s own’.

Interpersonal influence on the self is a main idea also in the role model theory. Roles can be defined as clusters of traits and behaviours for specific positions (McClelland, 1951), and role models are thus persons displaying a particular role. Role model research often concerns topics like who these role models are (e.g. Eccles, 2009; McIntyre, Paulson, & Lord, 2003) and role model characteristics (e.g. Lockwood, Jordan, & Kunda, 2002; Zirkel, 2002), with an emphasis on gender issues (e.g. Lockwood, 2006; Marx & Roman, 2002). Role models are a subgroup of significant persons as conceptualised by Woelfel and Haller. The following presentation of this conceptualisation is based on four articles written in the period between 1968 and 1972 (Haller & Woelfel, 1972; Woelfel, 1968, 1972; Woelfel & Haller, 1971).

Woelfel and Haller viewed attitudes as an individual’s conception of relatedness between the individual’s self and the object of the attitude. Applied to the educational choice setting this means that both the individual’s conception of herself and the individual’s conception of STEM will influence the individual’s valuation of a STEM-related educational choice. Any person who affects the individual’s view of herself or her view of STEM might contribute to a shift in her attitudes towards STEM.

Persons can exert influence on the individual’s view of self or object either through direct interaction with the individual or by being observed by the individual, being what Woelfel and Haller named definers and models, respectively. The definers communicate self- or object-defining information through direct interaction. The models exert influence by serving as examples of selves or by exemplifying objects without necessarily interacting with the individual. Building on Woelfel and Haller’s definition from 1972, a significant person is defined in this article as a person who either through direct interaction (a definer) or by example (a model) provides information which influences the individual’s conception of self or the individual’s conception of an object. The object is in the present case ‘STEM subject/education/career’. Note that in the original articles, Woelfel and Haller use the term ‘significant others’. This term is rewritten to ‘significant persons’ in this article due to the common interpretation of a significant other as someone with whom one has a sexual relationship.

This definition of significant persons provides us with four different categories of influence on a person’s choice to study (or not to study) STEM. A significant
person might (i) define the individual's self, (ii) define STEM, (iii) model a self, or (iv) model STEM. These categories are not mutually exclusive; one person might exert influence in all four ways. Role models are included in this definition as models of selves.

**Method**

*Project Lily*

The Norwegian project Lily is aimed at understanding the priorities, experiences, and motivational factors underlying young people's educational choice. Pen-and-paper questionnaires were used to collect the data in autumn 2008. Among the 14,000 respondents were 5007 students beginning a STEM-related education at a public university or a university college. They are the target group of this article. STEM students are defined in this project as students in engineering, graduate engineering, health-related subjects (pharmacy, pharmacy technician, and medical laboratory science, *not* medicine), informatics (e.g. programming and computer technology), the natural sciences (e.g. biology, chemistry, earth sciences, and physics), and mathematics (Schreiner et al., 2010).

All 26 universities and university colleges in Norway offering STEM educations are public. Twenty-five of these accepted the invitation to participate in project Lily. Local coordinators were appointed at all participating institutions. They were instructed to hand out pen-and-paper questionnaires to all new STEM students during the first week of the first semester. It took approximately 20 minutes to complete the questionnaire. The coordinators reported that 95–100% of the students chose to complete the given questionnaire. Nevertheless, the respondents of project Lily constituted only about 70% of the total number of STEM students who began their education in August–September 2008. This is partly due to the university college that declined to participate. Furthermore, some coordinators failed to administer the questionnaire to classes in the target group and some students were not present when the questionnaire was administered. These facts lead us to conclude that institutional factors and the workload of the coordinators account for the majority of students in our target group who did not respond. The proportions of women (33%) and men (67%) are the same for the respondents of project Lily as for the total population of Norwegian STEM students. Thus, we assume that the robust results in project Lily hold for the whole population of Norwegian STEM students who began their education in the autumn 2008. Since no sample is drawn, inferential statistical techniques will not be applied, e.g. sampling errors, confidence intervals, and significance levels are not reported.

The questionnaire was developed partly based on results and perspectives from previous empirical studies like ROSE – The Relevance of Science Education (Schreiner & Sjøberg, 2004) and theoretical perspectives like Eccles’ expectancy-value model (Eccles et al., 1983). A preliminary version of the questionnaire was evaluated by the coordinators and the reference group of project Lily based on their experience.
and knowledge of the respondent group. Steps were taken in the development process to validate the instrument. A pilot test was arranged where students completed the questionnaire and discussed it in a focus group. This made the researchers able to assess the respondents’ understanding of the items. Factor analysis of the final responses returned factors similar to those suggested by Eccles’ expectancy-value model. Thus, even though only single-item responses are analysed in this article, the validation indicates that the questionnaire functioned as intended. An excerpt of the items used in this article is given in the appendix. We will analyse and discuss 5 closed questions (Questions 14a–e), 2 open-ended questions (Questions 16 and 20), and 1 combined question (Question 19k).

Analysis of Closed Questions

Responses to the closed questions were given on a Likert scale with four response categories. Thus, there was no neutral middle category. This was chosen to prevent respondents from using a middle category as a I don’t know or I don’t care response (Kulas, Stachowski, & Haynes, 2008). The first box was labelled to a small extent and the fourth box was labelled to a great extent. The second and third boxes had no labels, which according to Cummins and Gullone (2000) might guide the respondents to interpret the relative distance between the boxes as equal. In coding the questionnaires, the four boxes were given values 1 (to a small extent) to 4 (to a great extent). The completed questionnaires were coded in SPSS 16.0. Independent re-coding indicated that 99.5% of the initial coding was correct. Missing values on the items analysed here range from 3.2% to 3.9%, except for the closed part of Question 19k, with 11.4% missing values. The high percentage of missing values of this question might be due to the design of the questionnaire, where this question is given at the end of a list of questions with the alternative does not apply (see Appendix). Some might have chosen not to answer this question as a ‘does not apply-response’ to indicate the small extent of inspiration from publicly known people in the media.

Analysis of Open-ended Questions

Responses to the two open-ended questions and the open-ended part of Question 19k will be analysed together. They will not be analysed separately because the questions overlap to some extent. Suggesting that a statement concerning significant persons means something different written as a response to, e.g. Questions 16 and 20 (see Appendix) will not contribute to our discussion in any important way. QSR International NVIVO 8 was used as a tool to organise the responses to the open-ended questions. All responses where a person is mentioned were selected for analysis. These were analysed by principles suggested in the literature on qualitative methodology (Robson, 2002) and coded with regard to:

(i) Who is the significant person? Every statement was coded with regard to who was mentioned. If a respondent wrote about the same significant person as a response to more than one question, this is only counted once.
(ii) In what way did the significant person contribute? Only statements containing more information than merely a name or a relation to a significant person were included here. The responses were coded in terms of the four categories defined by Woelfel and Haller: Significant persons define the self, define the object, model a self, or model an object. There is a sliding transition between these categories, and some responses were coded in more than one category. For example, the description of teachers as ‘smart people that give you confidence in yourself’ was coded both as modelling a self (‘smart people’) and as defining the self (‘give you confidence in yourself’). Two rounds of coding were conducted, and these provided the same result. Two other researchers have read both the responses and the forthcoming descriptions and confirmed that the descriptions reflect the students’ responses. Respondent quotes given in the next section have been translated from Norwegian by the author in collaboration with a native English speaker.

Results and Discussion

An overview containing quantitative results regarding significant persons in general and parents and teachers in particular will be given first. This is followed by in-depth descriptions of parents and teachers as significant persons organised by the Woelfel and Haller framework. Both the qualitative and the quantitative results are discussed consecutively. A general discussion follows this section.

The Role of Significant Persons in Respondents’ Educational Choice: An overview

The overall picture shows a moderate-to-small extent of inspiration and motivation from significant persons as reported by the respondents in the closed questions (Figure 1). Parents are attributed with a great extent of inspiration by 22% of the respondents, while 9% mark teachers as major sources of inspiration. Parents are
the only significant persons receiving a mean score above the scale midpoint of 2.5. A total of 41%, 2,066 respondents, attribute one or several significant persons with a major degree of inspiration.

Among the 5,007 respondents, a total of 1,664 significant persons are mentioned in the open-ended questions (Table 1). From Table 1 it is apparent that at least 84% of the significant persons mentioned in the open-ended questions (Rows 1–5) are people with whom the respondent has an interpersonal relationship. This result coincides with the general impression from Figure 1, where only 1% of the respondents attribute publicly known people in the media with a great extent of inspiration for the educational choice. Teachers receive the highest proportion of descriptions, adjusting the impression from Figure 1, where teachers were rated relatively low.

The responses where no person is mentioned are not analysed here, but they point to the obvious fact that also factors beside significant persons are significant. In particular, Norwegian STEM students express that the educational choice is made based primarily on personal interests and individual qualities (Schreiner et al., 2010). They have a clear impression of the educational choice as something depending primarily on their personality. This is probably the reason why persons were rated relatively low (Figure 1). However, the various descriptions of persons in the open-ended questions point to the importance of other persons (Table 1). Symbolic interactionism elaborates on how we come to know about ourselves through interaction with significant persons. Thus, implicit in the responses highlighting personality factors are perhaps some ‘definers’; significant persons who have helped the students learn about themselves.

Gender differences in the answering frequency to the open-ended questions were negligible. Over 90% of both women and men chose to write something in response to 1 or more of the 3 open-ended questions included in this analysis. There is, however, a major difference in what women and men chose to write about, and this difference is shown in Table 2: While there are twice as many male as female

<table>
<thead>
<tr>
<th>Table 1. Significant persons mentioned in open-ended questions</th>
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<tbody>
<tr>
<td><strong>Descriptions</strong></td>
</tr>
<tr>
<td>1. Teachers</td>
</tr>
<tr>
<td>2. Parents, fathers, mothers</td>
</tr>
<tr>
<td>3. Siblings, family, and relatives</td>
</tr>
<tr>
<td>4. Friends and sweethearts</td>
</tr>
<tr>
<td>5. Acquaintances</td>
</tr>
<tr>
<td>6. Other people*</td>
</tr>
<tr>
<td>7. Celebrities</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

*This group consists of a wide range of people, including students, counselors, STEM professionals, university employees, and general references like ‘people’ or ‘a person’.
respondents, there are almost as many descriptions of significant persons given by women as by men.

Table 2 shows that women’s emphasis on persons they know personally explains most of the gender difference concerning interpersonal influence. In particular, they were more than twice as likely to mention teachers as were men. This result supports the existing research: Gabriel and Gardner (1999) found that women describing themselves emphasised their relational self-views more often than men. While men described themselves in terms of individual or collectivistic traits (the traits of the group they belong to), women highlighted who they were in relation to the individuals they knew. Zeldin, Britner, and Pajares (2008) claimed that women rely more heavily on interaction with others to build self-efficacy, which is an important explanatory factor for educational choice (Eccles & Wigfield, 2002). This might be the reason why so many teachers, given the opportunity to influence specific self-views concerning STEM abilities, are mentioned by women compared with men.

Table 3. Fathers, mothers, and parents mentioned in open-ended questions

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fathers</td>
<td>181/72</td>
</tr>
<tr>
<td>2. Parents</td>
<td>96/56</td>
</tr>
<tr>
<td>3. Mothers</td>
<td>27/21</td>
</tr>
<tr>
<td>Total</td>
<td>304/149</td>
</tr>
</tbody>
</table>

*Does not sum up to 100% due to round-off error.
difference in the STEM labour reported in Norway is an important reason why this is, indicated by the various descriptions of fathers who are or have been engaged in a similar subject area. These fathers have been models, displaying self engagement in STEM. To the extent that mothers are described as having inspired or motivated the respondents, they have been relatively more often inspired through personal support and conversations, thereby defining the students’ selves. Twenty-one of the 27 descriptions of mothers are given by women, underlining the discussion in the previous paragraph: Women seem to use significant persons to help them define their selves more frequently than do men.

According to the background information given in the questionnaire, almost half of the respondents have at least one STEM-educated parent. Not surprisingly, these students are the ones claiming to be most inspired by a STEM-related educational choice by their parents (Figure 2). Note, however, that almost half of the students with no STEM-educated parent ticked off in the top two categories as a response to whether or not they were inspired by a STEM-related educational choice by their parents. Thus, parents can be important inspirers for STEM without themselves being (professionally) involved in it. This is related to the important function of parents as STEM inspirers through defining the young person’s self. A significant person does not need STEM training to influence a choice of STEM education.

Figure 2. Degree of inspiration from parents

Figure 3. Degree of inspiration from teachers
Student groups differ in how inspired they claim to be by teachers. Students in disciplines that also exist as subjects in school, like chemistry and biology, are the most likely to report inspiration from a teacher. That is, teachers inspire a choice of education within chemistry, biology, mathematics, and physics more frequently than they inspire a choice of education within ‘applied’ STEM subjects such as computer science, engineering, and geosciences (Figure 3). Almost every third chemistry student claims to be inspired to a great extent by teachers, while every twenty-fifth computer science student claims the same. In the open-ended questions we find the same pattern, where few students in applied STEM subjects mention their teachers. This might be due to a role model effect, where teachers with theoretical STEM training inspire the choice of a similar subject through modelling. Moreover, this might be due to a lack of practical and work-relevant STEM training in Norwegian classrooms. Relating their subjects to real-world applications could possibly help teachers inspire choices of applied STEM educations. Many Norwegian students seek ‘meaningful’ activities with the opportunity to ‘help other people’ in a future career (Schreiner et al., 2010). Modelling STEM applied to societal challenges could thus serve as an important inspirational source.

The numbers of responses holding sufficient information to be coded in terms of Woelfel and Haller’s four categories are given in Table 4. The forthcoming descriptions of parents and teachers as significant persons are based on these responses.

Parents and Teachers Defining the Self

According to Woelfel and Haller (1971), an individual’s conception of self is a decisive factor for educational choices. In the present study, respondents describe parents and teachers as influencing different aspects of the self. We have a distinction between those who influence global self-views and those who influence specific self-views (Swann Jr & Bosson, 2010).

Parents. Many respondents highlight how conversations with parents have been important for their global self-view, where main characteristics and general knowledge about the self are communicated. Some have been told by their parents that they can achieve whatever they want, and some have been coached to identify and develop their interests: ‘Was coached by my stepmother and consequently I discovered what I really wanted to do and what really interested me’. Parents giving

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Table 4. Responses coded in Woelfel and Haller’s framework

<table>
<thead>
<tr>
<th>Category</th>
<th>Parents</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Defining the self</td>
<td>24</td>
<td>15</td>
</tr>
<tr>
<td>2. Defining STEM</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>3. Modelling a self</td>
<td>67</td>
<td>63</td>
</tr>
<tr>
<td>4. Modelling STEM</td>
<td>43</td>
<td>19</td>
</tr>
</tbody>
</table>
advice about suitable educations are at the same time telling youngsters something about who they are. For some respondents, a small suggestion or a single conversation was enough. Others were convinced as a result of repeated appeals or parents’ persistent wishes: ‘My father is a graduate engineer in electronics, so obviously I have been nagged (…)’. There is a gradual transition from support to pressure. Some write about what their parents expect of them, and other respondents refer to parent pressure as a reason for their educational choice: ‘(…) was strictly speaking pushed in by my parents. They wanted me to be something great’. Most descriptions are, however, more positively loaded and the respondents trust their parents to help them define who they are. Even grandparents are described in this fashion, providing a powerful example of how a significant person can help young people define their global self-views: ‘My grandmother has had a great influence for the person I have become and has been involved in setting the goals, wishes, and dreams in my life’.

Teachers. Teachers’ support and encouragement have been of great value for the specific self-view of many respondents, influencing how they view specific parts of their selves. Partly due to this support some have let their interest grow with regard to particular subjects: ‘Had a good and attentive biology teacher in upper secondary school, who gave continuous support when he discovered that I was interested in this subject’. Other teachers encourage and support their pupils with regard to educational choices and future plans: ‘When I mentioned to my teacher that I considered applying to biology, she expressed that it was a good choice for me and that probably was part of why I applied’. Some teachers not only support the existing plans, but make suggestions: ‘At junior high school I was told by my science teacher that I ought to go into science’. Good teaching can bring out young people’s abilities. This way, teachers contribute to their pupils’ joy of learning and help them discover their STEM talents:

Been having good, motivational math and science teachers since primary school. This has contributed to my long-lasting feeling about the fact that math was something I was good at. This is one of the main reasons why I now have chosen this study programme.

Through conversation and support parents have functioned as important significant persons, including some without background in STEM (Figure 2). They demonstrate how crucial the global self-view is for the educational choice. Fathers, but in particular mothers, were described to have contributed to a choice of STEM through conversation and support. Moreover, some respondents described how their parents held expectations of them. Parents’ expectations are particularly influential because of the high degree of exposure in such close relationships (Baumeister, 1999). Higgins (1987) wrote about the actual, the ideal, and the ought self. Parents’ expectations may contribute to the ought self, giving the young girl or boy ideas about what they should be like and what they ought to do in a future career. Teachers, on the other hand, help pupils define their actual selves, focused around specific self-views. Through interaction with teachers pupils come to learn about and develop their skills and abilities, thus influencing their expectation
of success within STEM. People are more likely to undertake activities when they believe they can produce desired effects (Eccles & Wigfield, 2002), and this clearly applies to the choice of a STEM education.

**Parents and Teachers Defining STEM**

Knowledge about different subjects, educations, and careers are intuitively of great importance for someone making an educational choice. During the last 10 years young people have increasingly turned to the Internet for such information. Parents and teachers are, however, still important sources of information.

**Parents.** Mothers and fathers ‘always talking eagerly’ about a subject or explaining its content have considerable influence: ‘It was a hard choice, but my father has the same education, and when I was told what marine technology is about, I wanted to study marine technology’. Information about different educations is also important. Some parents highlight the study content, and others highlight the social life as a student at a specific educational institution: ‘Have parents and siblings who studied at the Norwegian University for Science and Technology. Thus I am told a lot about the study and the social set. And it seems nice’. Information about different careers is communicated both by parents telling youngsters about what is actually happening at their workplace and by sharing their personal experience of working with this subject: ‘My father is a geologist and has always expressed how he loves what he does, and as a consequence I have developed interest for the subject’. Most commonly, parents share information about a subject, an education, or a career they themselves have first-hand knowledge about.

**Teachers.** Some teachers, in addition to teaching the subject, talk about the subject, thus defining it: ‘Teachers at the schools I went to described physics as a very versatile subject, lots of mathematics. It fits my personality’. They also inform about specific educations: ‘Had a teacher at upper secondary who introduced me to the engineering pre-course and said it was a nice way to combine vocational courses and university admission certification’. Several teachers have valuable insight into matters of scientific research, and this has been of significance for some pupils: ‘Information about CERN given by my physics teacher’.

Parents and teachers have shared a wide range of information. To define a subject, some have told respondents about what kind of skills are necessary, and others have told about the content of the subject. To define an education, some have told about the study content, and others have told about what opportunities this education offers. Careers are defined both by telling about what is actually happening at work and by sharing the personal experience of working there. In all, different respondents highlight different kinds of information that have influenced their educational choice. This fact is an important reason why significant persons in interpersonal relationships with young people are key informants regarding STEM: A person who knows the young girl or boy personally may also know what information the future student
seeks. This opportunity is missed by institutions and marketing companies designing brochures, commercials, and campaigns.

**Parents and Teachers Modelling a Self**

By modelling selves that relate to STEM, parents and teachers can increase the spectrum of STEM-related roles available and attractive for young people. Parents often model a STEM-related self which is overlapping with the young girl or boy’s self, thus making the choice of STEM an obvious and natural choice. Teachers display how much inspiration and joy STEM can bring to one’s self.

**Parents.** Many students have mothers, but most often fathers, with the same education as they themselves pursue: ‘My father has the same education, and he has done well’. As such role model parents have displayed how personal factors like enjoyment and professional factors like employment opportunities are associated with a person with this education. Several students underline how choosing a particular education or career came naturally because a parent (or both) once made the same choice: ‘Both my parents studied this. Have always known that this is something for me’. Abilities and interests seem to come with the heritage: ‘My mother does this. Thus it may come naturally to me’. The role model effect is strong, and respondents write things like: ‘My father is an engineer and I have always admired that’ and ‘My father with a management position with engineering background has always served as a great example’. Moreover, parents can be role models without necessarily having a career within STEM: ‘My father has always been interested in new technology, and so have I for a long time now’.

**Teachers.** Many students inspired by their teacher highlight what it is about the teacher that inspired them. One of the factors highlighted is their professional background and their competence: ‘Teachers I look up to with great competence in mathematics and physics’. Another influential aspect of the selves modelled by teachers regard their passion about STEM. Many students describe their teachers this way, using words like ‘enthusiastic’, ‘inspirational’, and ‘engaging’. Some teachers ‘really loved the subject’ and ‘were excited about what they taught’. Their passions have inspired many STEM-related educational choices. Teachers have shown pupils how a person involved in STEM can be ‘attentive’, ‘nice’, ‘entertaining’, ‘helpful’, ‘pleasant’, and ‘kind’. A considerable number of respondents describe their educational choice as a result of ‘good teachers’: ‘Had an unbelievably smart teacher in biology at upper secondary that made me develop interest for the subject’. Students report how good teachers made the subjects ‘exciting’, ‘fun’, and ‘easy to learn’, they made them ‘feel good about’ the subjects and developed their joy of learning; all factors supporting a choice of STEM education.

Lyons and Quinn (2010) conclude that the most important reason for not choosing science among year 11 pupils in Australia was that they could not picture themselves as scientists. This is perhaps part of the reason why many respondents highlight the
importance of role models; significant persons modelling a self (Table 4). Common for most descriptions of parents modelling a self, is the fact that they have been engaged in STEM activities themselves. Teachers are linked to the STEM subject they teach. Conclusively, those engaged in STEM themselves are in a special position to inspire a choice of STEM. Moreover, symbolic interactionist Mead (1934) wrote that a young person ‘is continually taking (...) the roles of those who in some sense control him and on whom he depends’ (p. 160). Due to the accessibility of the roles of parents it is not a surprise that young people often choose to take the same role as a mother or a father. It is simply ‘easier to solve the problem in this way than it is to find a solution through trial and error’ (McClelland, 1951, p. 304). Many respondents describe STEM as an obvious and natural choice because a parent made the same choice. Some seem to assume that having a parent with certain characteristics implies that they themselves have the same characteristics. This is the phenomena Aron et al. (2004) describe in the self-expansion theory: If closeness to a significant person grows, the young girl or boy might experience a cognitive overlapping of self-concepts. One might say that the significant person modelling a self in this way also affects the individual’s self-view, thus contributing to how the individual defines herself.

The significant persons most frequently mentioned in the students’ descriptions were the teachers. They are, in contrast with the parents, with a ‘hereditary component’, described in terms of their affective relationship to STEM. Teachers have showed many respondents how these subjects can be integral parts of an identity in a positive way. They increase young people’s spectrum of attractive and suitable roles within STEM.

Parents and Teachers Modelling STEM

Parents and teachers can inspire a choice of STEM by giving young people an experience with STEM subjects or careers. The respondents emphasise the importance of hands-on experiences and seeing real-world applications of STEM.

Parents. Several respondents describe how their parents have introduced them to STEM subjects: ‘My mother and my grandfather are geophysicists, and they have gradually introduced me to the world of geology’. Different activities and experiences with parents are of importance for the educational choice. Students write about playing with microscopes, travelling to architectonic masterpieces, and tinkering with cars, and they highlight how parents through these activities have produced first-hand experiences, thus modelling a particular subject. Many of these experiences have taken place at parents’ workplace. Girls and boys have tagged along their fathers at construction sites, and others have been exposed to ‘miniature installations’ and ‘enjoyable chemical experiments’ at parents’ work: ‘My mother is a science teacher and brought me to the school laboratory to conduct experiments’. Parents sometimes have the opportunity to model a subject which is unfamiliar to most young people: ‘My father works offshore. It was during a family day, when families could come to the platform and see what it is like there, that my interest really kicked in’.

Young People’s Choice of Science in Higher Education 15
Teachers. Some teachers have created interest for a subject through modelling a particular topic: ‘My biology teacher at upper secondary school made my interest for biology grow, in particular for the technological and molecular part’. Several students credit their teachers for showing them the fun and enjoyable aspects of different subjects: ‘Had a very smart chemistry teacher and did many fun experiments in the chemistry lessons at upper secondary’. Through school-related activities teachers model STEM, as when pupils get to experience the practical methods of science through laboratory work. Some teachers arrange excursions to educational institutions and industrial companies: ‘Trip to Trondheim with a chemistry teacher for a visit at StatoilHydro’ [an oil company research centre].

To choose a career without knowing anything about it is unlikely. This is probably why workplace visits are so frequently mentioned by the respondents. First-hand experiences with STEM both display the enjoyable aspects of these subjects and give assurance related to what is going on at work. The observed work activities and work environment might supplement the youngster’s ideal self (Higgins, 1987) with both some performances and a location. Teachers, on the other hand, have modelled different STEM subjects more generally. Good teaching has created great interest for many respondents. Thus, roughly speaking, while parents affect the global self-view and display specific STEM careers, teachers affect the specific self-view and display STEM subjects in general.

General Discussion, Limitations, and Implications

This article provides empirical support for claims about the importance of interpersonal influence for educational choices. Every third respondent wrote about a person when the educational choice was described, and over 40% ticked off a significant person as having major influence. Thus, at least every third respondent regards a person as highly influential for the educational choice.

This study also highlights the importance of youngsters’ self-perceptions when educational choices are made. Symbolic interactionism points to the reason why those in interpersonal relationships with youngsters are particularly important for their self-development. The looking-glass self, as described by Cooley, is self developed through the eyes of others. By interpreting other people’s actions towards, and responses to, their selves, young people continuously revise their understanding of themselves. Thus, girls and boys learn about themselves through the persons with whom they interact. According to Woelfel and Haller, this knowledge about one’s self is a major element in developing an attitude towards an object. These theoretic claims coincide with the empirical claims in the present study. The quantitative and the qualitative analyses have one thing in common: The significant persons with greatest significance are the ones who know the girls and boys personally. Woelfel and Haller’s definition of significant persons includes celebrities. The celebrities, however, receive a low rating in the closed questions, and few respondents describe them in the open-ended questions. Practically speaking, all persons attributed with a great extent of influence for the choice of a STEM education were someone with
whom the student had an interpersonal relationship. Through their interactions with parents and teachers, many youngsters have come to consider themselves as sufficiently interested, suitable, and skilled for a STEM education. Symbolic interactionism and the results presented here thus point to the importance of involving opportunities for interpersonal relationships when designing recruitment initiatives.

This study illustrates how the framework of Woelfel and Haller regarding significant persons is suitable in order to investigate interpersonal influence and attitude change. According to Woelfel and Haller, attitudes towards STEM are influenced by those who communicate information about the youngsters or about the STEM subjects, those who model a STEM-related self or the STEM subjects. Thus, the persons capable of influencing young people’s attitudes towards STEM are those who know the youngsters personally, those with knowledge about STEM, and those who are STEM practitioners. Teachers and parents, in particular parents engaged in STEM, are in a special position to meet these criteria, exemplified throughout this article.

These results support the conclusion of Buck et al. (2008) where the interpersonal relationship was identified as a key factor for attitude change among girls towards STEM scientists. Nauta and Kokaly (2001) concluded in their research that significant persons influence academic choices to a great extent by providing support and guidance. Again, the ones who know the youngsters personally are in a special position. Holmegaard (2011) describes how students in the process of choosing higher education struggle to construct a narrative around their choice that makes it appear personal and unique. This narrative also has to be recognised as such by the student’s family and friends, and the educational choice is described as ‘an ongoing process over time, moving back and forth between identifying own interests, constructing a convincing narrative and trying it out on social relations’ (Holmegaard, 2011). Interpersonal relationships are essential for anyone defining themselves, which is crucial for the educational choice.

Limitations

The objectives of this article regard significant persons and their influence on STEM-related educational choices. Parents and teachers are highlighted as important significant persons. We cannot, however, use these results to get an exact measure of parents’ and teachers’ influence relatively to the influence of, e.g. other STEM experiences, cultural patterns, or personal STEM interests. Self-reports concerning influence contain only the conscious part of a subtle and complex matter. Moreover, since nobody knows the precise range of interpersonal influence, we cannot exclude the possibility that factors regarding significant persons may exist that are not mentioned by the respondents. Another limitation regards the outcome of the reported influence. In most cases, we do not know if the significant person inspiring ‘my choice of education’ has inspired a university education in general, a STEM education in general, or a specific STEM education.

To meet these limitations, more precise and in-depth instruments must be applied. The main results in this article, however, provide valuable and valid insight into matters of interpersonal influence for STEM-related educational choices. The
broad outlines of the quantitative results, the many responses providing the qualitative results, and the theoretical perspectives all contribute to the main conclusions, thus strengthening the validity.

**Implications**

The main result regards all significant persons, and points to the following implication: Anyone seeking to influence young people’s attitudes towards STEM should look for ways to involve those who know the girls and boys personally. To improve recruitment, initiatives could be aimed not only at the young people themselves, but also at those who have interpersonal relationships with the future STEM students. The global self-view is relevant to a STEM-related educational choice. Thus, also persons without any STEM training can be involved in projects enhancing a choice of STEM. Using persons the young people know personally as mediators, there is a greater chance that they in fact will be influenced. ‘Spectacular’ improvements were reported when mothers were trained to teach their daughters mathematics (Frost, Reiss, & Frost, 2005), demonstrating how such a recruitment initiative might work.

Information material about STEM subjects, educations, and careers should be distributed to parents, teachers, and other persons who have interpersonal relationships with young people. If they read about the different aspects of STEM-related educational choices, they can identify and promote the information that is interesting and relevant to the youngster. Different girls and boys have different abilities, interests, and opinions. Only those who know the youngsters personally can provide the kind of guiding, inspiration, and information they need to have a possible career for themselves within STEM.

Family days at work places have been highly important to many STEM students, and such initiatives should be taken by companies and institutions that need to increase recruitment. They should furthermore encourage their employees to talk about their work in social settings involving young people. Many students chose their education because their parents introduced it to them. However, some respondents described how their parents pressured them to choose a particular education. Thus, parents should be aware not to force their girls and boys to choose STEM at any cost.

Companies, institutions, and government bodies should support teachers with teaching material developed to bring real-world applications into the classroom. This might inspire more pupils to study applied STEM subjects. We have seen that teachers have great influence on young people’s specific self-views. This is important for girls in particular, who are shown to have an unrealistically low self-efficacy in STEM (Lyons, 2006). Teachers must communicate to girls a realistic image of their abilities. This might encourage them to choose STEM in higher education.

Some implications concern future research. Woelfel and Haller’s conceptualisation of significant persons is found to be a suitable framework for capturing the various ways in which significant persons inspire young people’s educational choices. This
framework provides categories and descriptions enhancing fruitful discussions on interpersonal influence. Future research on significant persons may apply this framework to develop well-targeted research questions and to organise data material. The conceptualisation can also be developed and applied to new settings.

Future research should explore the opportunities of engaging parents, in particular those without a STEM background, to promote STEM-related educational choices. A thorough description of the ways in which teachers inspire educational choices is valuable. Mentoring programmes and other initiatives involving meetings with people involved in STEM should be investigated in order to deepen the understanding of how those who have interpersonal relationships with young people influence their choice of a STEM education.

References


Appendix

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

<table>
<thead>
<tr>
<th>Description</th>
<th>Very important</th>
<th>Not important</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>□</td>
<td>□</td>
</tr>
<tr>
<td>e. Other people I know</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Statement</th>
<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>
<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>
<td>□ □ □ □ □</td>
</tr>
</tbody>
</table>

13. 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?

14. 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, cafe, library, reading rooms, sports facilities and so on)

15. 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>

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

<table>
<thead>
<tr>
<th>Factor</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) (does not apply)</td>
<td>□ □ □ □ □ □</td>
<td>□ □ □ □ □ □</td>
</tr>
<tr>
<td>e. Information folders from the university (college) (does not apply)</td>
<td>□ □ □ □ □ □</td>
<td>□ □ □ □ □ □</td>
</tr>
<tr>
<td>f. The Internet pages of the university (college) (does not apply) ...</td>
<td>□ □ □ □ □ □</td>
<td>□ □ □ □ □ □</td>
</tr>
<tr>
<td>g. Visit from the university (college) to your school (does not apply)</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. Publicity known persons in the media .......................................</td>
<td>□ □ □ □ □ □</td>
<td>□ □ □ □ □ □</td>
</tr>
</tbody>
</table>

If so, who? Other comments: ........................................................................

18. Can you name one or more experiences or activities from your background that have influenced your current choice of education? (Describe 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.)
ARTICLE II

Title: Increased motivation for science careers? Investigating a mentoring project

Authors: Jørgen Sjaastad and Fredrik Jensen

Under review: International Journal of Science and Mathematics Education

Authors’ comment: The manuscript printed here is a slightly improved version of the manuscript submitted to the International Journal of Science and Mathematics Education
Increased motivation for science careers?
Investigating a mentoring project

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**ABSTRACT**

Considerable resources are spent on recruitment initiatives aiming to inspire adolescents to pursue educations within science, technology, engineering and mathematics (STEM). However, the extent of published research on the effects of recruitment initiatives is limited, and so far it seems like an understudied area. Drawing on focus group interviews with participants in ENT3R, a Norwegian STEM mentoring programme, the aims of this study are to generate knowledge about what participants appreciate about such projects and to discuss the ways such projects might influence participants’ choice to pursue or not pursue STEM educations. These aims will be addressed here in the case of the ENT3R project. The authors identify four aspects of the project highlighted by the participants: the mentors provide good teaching, create a positive atmosphere, engage in interpersonal relationships and are positive role models. Moreover, drawing on Eccles and colleagues’ expectancy-value model for educational choices, the authors conclude that ENT3R might potentially influence all five factors held up by the model as important for educational choice. This study points to the benefits of providing participants with a variety of experiences, the benefits of letting the participants take part in a project over time, and the importance of carefully recruited and trained mentors.

**Keywords:** Educational choice, Mentoring, Motivation, Out-of-school projects, Recruitment, Role models, STEM careers.
BACKGROUND AND PURPOSE

Every society needs people with competence in science, technology, engineering and mathematics (STEM), as elaborated on in several reports and articles (e.g., EU, 2004; Osborne & Dillon, 2008). In Norway, as in many Western countries, concerns about the number of students choosing STEM in upper secondary and tertiary education have led government, industry, educational institutions and private actors to initiate projects to increase recruitment to these subjects. Considerable resources are spent every year on recruitment initiatives, and these might play a role in the formation of adolescents’ values, interests and aptitudes, thereby influencing educational choices. Thus, in order to fully understand educational choices, the role of recruitment initiatives needs to be considered, and knowledge about the outcomes of these and how they can be improved is of great interest.

Searching for literature on recruitment efforts, the most striking result is the low number of research articles on this matter, indicating that it is an understudied area. In the research articles that do exist, a great variety of initiatives appears, including elements like laboratory activities (e.g., Barmby, Kind, & Jones, 2008) and career presentations (e.g., Cantrell & Ewing-Taylor, 2009). Most publications regard single events, and these have different target groups and different approaches. The majority of events are held at university campuses, ranging from single day events to week-long summer camps. A common response given by participants of such events is that they enjoy doing practical hands-on science activities (e.g., Swimmer & Jarratt-Ziemski, 2007; Woolston, Zaki, & Winter, 1997). In most instances, participants meet students or faculty staff at the institutions. The importance of the personal meeting between participants and tertiary students and/or staff is probably the most recurring factor in the publications reviewed here (e.g., Anderson-Rowland, 1996; Anderson-Rowland, Banks, Zerby, & Chain, 2005; Swimmer & Jarratt-Ziemski, 2007; Vollstedt & Wang, 2006; Woolston et al., 1997). Finally, the importance of evaluating and adjusting recruitment initiatives is pointed to by Bischoff, Castendyk, Gallagher, Schamloffel and Labroo (2008). They studied a project where upper secondary students participated in week-long science camps at a college in the USA. Every year, the camp was evaluated and adjusted accordingly. Drawing on both questionnaire data and increased enrolment numbers, the researchers claimed that the camps were a success. Bischoff and
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colleagues concluded that the many rounds with evaluations and adjustments were critical in making the event successful.

Concerning educational choice, researchers point to several reasons why many girls and boys do not wish to study STEM, three of which will be mentioned here. Firstly, mathematics and science are generally perceived to be more difficult than other subjects (e.g., Bøe, 2012; Lyons & Quinn, 2010). Secondly, the career opportunities provided by STEM educations are unknown to many young persons (e.g., Cleaves, 2005), and thirdly, the stereotypical image of scientists does not fit many young persons’ perceived identities (e.g., Taconis & Kessels, 2009), claiming that ‘I can’t picture myself as a scientist’ (Lyons & Quinn, 2010). The Norwegian STEM mentoring project ENT3R was designed to counter these reasons for not choosing STEM. The purpose of the present work is to investigate this recruitment initiative with respect to two dimensions: firstly, it is valuable to know what the participants appreciate about the project, making them attend the project voluntarily. Secondly, it is necessary to know if the participants’ experiences of the project heighten the probability of them choosing a STEM education. This knowledge will not only inform the development of ENT3R, but it will also be useful to persons interested in participation in STEM, and specifically to persons involved in similar recruitment efforts. On this basis, the authors will answer the following two questions:

1) What do the participants in ENT3R appreciate about the project?

2) In what ways might the participants’ experiences of ENT3R promote the choice of a STEM education?

The ENT3R project

The Norwegian mentoring project ENT3R (The RENATE Centre, 2011) was initially a merger of two recruitment initiatives, developed individually over three years at two universities in Norway. They were both initiated to inspire adolescents to choose STEM in upper secondary and tertiary education, and ENT3R is an attempt to pursue the promising elements of both efforts. The project is funded by the Norwegian Ministry of Education and Research and different organisations representing trade and industry. The main idea of ENT3R is to create interest in STEM educations, which is done by providing adolescents with science role models, by improving their skills and confidence in mathematics, and by providing examples of the utility of STEM. ENT3R offers weekly maths trainings and
monthly STEM career nights to achieve this. The mentors, who study STEM at university level, hold key positions in the project: the underlying assumption is that youngsters’ personal meetings with these students will help them see themselves as potential STEM practitioners. After three years, having undergone evaluations and continuous development, ENT3R is now implemented in all universities and university colleges in Norway offering STEM educations. A total of 175 STEM students are now mentors for the 2100 participants in the project. There are slightly more girls than boys in ENT3R.

In recruiting participants, representatives from ENT3R visit schools to promote the project, and the students voluntarily sign up for a mentor group consisting of two mentors and about 10 students. ENT3R is free of charge, and about 50% of the students who participate in the first maths training stay in the project throughout the semester or longer. Most participants are 15 to 17 years old and are students in their last year of lower secondary or their first year of upper secondary school. This is the period when students in Norway choose specialisation for the last years of upper secondary, which is decisive for a potential tertiary STEM education. The participants might stay in the project throughout upper secondary, so there are some 18- to 19-year-olds in the project as well. In ENT3R, participants go to their local university or university college once a week to meet their mentor group for two hours of maths training after school. Students with different ability levels participate, from those hoping to pass a science or mathematics course, to those who want challenges more difficult than their school teacher can provide. Three different reasons for participating in ENT3R occur frequently: (1) Some are interested in mathematics and wish to spend more time doing maths. (2) Some find the subject challenging and want extra help, and (3) some want inspiration to do homework and seek an environment free from distractions such as Facebook or TV. Regardless of reason for participation, the ENT3R project is considered relevant for most students with regard to participation in STEM. For instance, persons providing reason 1 might not be convinced that STEM careers are sufficiently important with respect to something else they value, and persons providing reason 2 might not know whether they are able to pursue an education involving science and mathematics. Thus, even though they already voluntarily participate in a STEM mentoring project, they are still an important target group with respect to participation in STEM.

The mentors are selected through a thorough application process. The minimum requirement in order to apply for a position as a mentor is to be among the top 50% of
students in university calculus course exams. Professional teacher educators and leaders in ENT3R evaluate the best applicants through interviews and trial lectures. The employed mentors meet every semester for seminars regarding teaching activities and mentoring. They are bachelor or master students in different STEM fields; physics, mechanics, chemistry, informatics, technology, mathematical finance and pure mathematics. What they have in common is the introductory university calculus courses.

The maths trainings in each ENT3R group are led by two mentors, and a wide range of STEM-related activities take place. The mentors might give mathematics presentations, they might help the participants with science and mathematics homework, and they might arrange for games and riddles related to STEM. They might present to the students what they themselves are studying, like physics and chemistry, and they might bring the participants along to laboratories and other places at the university campus. Every fourth week, all ENT3R groups meet for STEM career nights, where companies drawing on STEM competence arrange activities in order to show how STEM is used in different professions.

**ECCLES AND COLLEAGUES’ EXPECTANCY-VALUE MODEL**

Bøe and colleagues (2011) examined international research on young people’s attitudes towards and participation in STEM using Eccles and colleagues’ expectancy-value model for achievement-related choices (Eccles et al., 1983; Eccles & Wigfield, 2002), and concluded that the model is ‘not only useful for understanding young people’s participation in STEM, but for designing and evaluating initiatives’ (Bøe et al., 2011, p. 63). Thus, this model fits well with the aims of the present study. It is comprehensive and captures key components influencing individuals’ choice of education. According to the model, a student’s motivation for an educational choice consists of two main aspects: the expectation of success and the subjective task value attributed to the education in question.

The *expectation of success* is the individual’s thoughts about how well he or she will do on an upcoming task: ‘Will I be able to go through with this? Is it likely that I will successfully reach the goals I set for myself? Four components are included in the subjective task value. *Attainment value* is related to identity: ‘How well does this task match my perceived identity? Will this task confirm or develop who I am? How important is it for me to be engaged in this task and do well? *Interest-enjoyment value* is related to intrinsic motivation: How enjoyable is the task? Will I have fun doing this? Am I interested? *Utility value* is
related to extrinsic motivation: How will this task help me reach other goals I have set for myself? Does this activity contribute to more important projects I have?

The greater the expectation of success, attainment value, interest-enjoyment value and utility value, the greater probability of choosing to engage in a task. The fourth subjective task value, namely cost, is related to negative aspects. Greater cost leads to lessened probability of engagement in the task: Will this activity be at the expense of other activities? How much time and effort will it take? What do I risk in terms of failure and anxiety?

Eccles and colleagues’ expectancy-value model links expectancies and subjective task values directly to performance and choice. Applied to the educational choice setting, the model seems all-inclusive, that is, most arguments and influences concerning educational choice can be related to one or more of the five main components proposed by the model. The model is used in two ways in the present study. Firstly, it is used to generate ideas for focus group interview questions. Secondly, the model is utilised to answer the second research question; it suggests components that influence educational choices, and it is investigated whether the experiences shared in the focus groups are examples of these components, thus being experiences that might promote a choice of STEM.

METHODS

Data collection

In order to investigate the ENT3R participants’ experiences of the mentoring project and the potential impact on their educational choices, the authors chose to conduct focus groups (Morgan & Krueger, 1998), being an efficient and flexible way to bring out a breadth of experiences. Prior to developing the interview guide, the authors interviewed two mentors and two leaders in ENT3R. This insight and Eccles and colleagues’ expectancy-value model were used to generate ideas for topics to include in the focus groups. The authors were continuously supported by colleagues with focus group experience, for instance, they took part in phrasing the questions. The final interview guide (see Appendix 2 in thesis) has two introductory questions, three main questions (concerning participants’ experiences of ENT3R, their educational plans and their relationship to the ENT3R mentors), five collections of subquestions related to the five categories in Eccles and colleagues’ model, and three closing questions.
The sample in this study is participants in ENT3R at the University of Oslo (UiO), having about 40 mentors and 300 participants. These participants were chosen because ENT3R at UiO is regarded as leading the way as an example for ENT3R at other institutions, and this is thus assumed to be a good place to look for positive effects of the project. Moreover, only participants who had been in the project for at least one semester were invited to the focus groups, since these persons were likely to have a variety of experiences to share. The authors randomly chose four mentor groups. A total of 25 participants, having eight different mentors, took part in a total of four focus groups, spread out over a period of two weeks. The 11 girls and 14 boys, most of them 15- to 17-year-olds, but some of them 18- to 19-year-olds, represent the ENT3R participants well with respect to both gender and age distribution.

Note that there is no input from students who attended ENT3R for only a few maths trainings and then decided to quit. This is a limitation of the present study. It would be interesting to investigate why those who decided to quit did so, but in order to answer the research questions, it was necessary to speak with persons having a variety of experiences of ENT3R, that is, persons who had spent a certain amount of time in the project.

The focus groups took place immediately after the participants’ maths trainings, and started out with about 30 minutes of small-talk and pizza to make the participants feel comfortable and confident to talk. Then the actual discussions began, which normally lasted about 45 minutes. The two authors participated actively as moderators in all four focus groups. With the participants’ permission, a sound recorder was used during the conversations. After the introductory questions, the first main question was given: ‘Could you tell us how you experience participating in ENT3R?’ This open-ended formulation was chosen in order to get the participants’ views with as little influence as possible. Drawing on participants’ spontaneous answers to this, the authors identified which collection of subquestions, categorised according to the components in Eccles and colleagues’ model, this was a specific answer to, and used the relating questions to guide the conversation. When all aspects of this theme had been discussed and the participants had nothing to add, the authors returned to one of the three main questions. After all main questions and subquestions had been covered in some way, and when the participants did not bring up any new experiences, the closing questions were asked. These had two functions. Firstly, having discussed the project with their peers, their summaries of important aspects of the project were likely to be
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well reasoned. Secondly, it gave the participants an opportunity to mention experiences not covered by the interview guide. Finally, the authors shared their impressions from the discussion for the participants to comment on.

**Analysis**

Immediately after the focus group participants had left, the authors discussed their main impressions. The following day, the focus group was discussed further. That is, the analysis process began with discussions in-between the focus groups. The fourth focus group added only minor details to the authors’ understanding of ENT3R. Theoretical saturation was perceived to be adequately reached, and the authors decided to stop collecting data.

The sound recordings were transcribed by the authors in order to get a second experience with the conversations. Computer software NVIVO 8 (QSR International Pty Ltd., 2008) was used to code the material. The focus group data was coded in two ways in order to answer the two research questions. In order to answer the question regarding what the participants appreciate about the project, the authors separately coded the material several times inductively. Over a period of ten months, the authors met frequently to discuss their interpretations of the data material. These discussions generated ideas for new ways to investigate the data material and deepened their insight into the project. Gradually, the authors converged towards a shared understanding of the data material. The decision for a final coding structure was made, and the data material was coded once more according to this. In order to answer the second research question, the data material was coded deductively according to the five components in Eccles and colleagues’ expectancy-value model. In this instance, the authors identified all quotes exemplifying the different components in the model. Quotes exemplifying the codes are given in Appendix 6.

**Validity**

The results of this study will be drawn mainly from quotes from focus groups. To strengthen the interpretation of these discussions, the authors took several steps. Firstly, the authors met with two of the mentors and two of the leaders of ENT3R. They shared their thoughts about the project and about being mentors. Secondly, the authors were present at maths trainings before and in-between the focus groups in order to observe what the participants were describing. Moreover, the interpretations are partly confirmed by the participants: at
the end of the focus groups, the authors shared their understanding of the discussion. The participants were encouraged to comment on this and to reject or supplement where necessary. Finally, in the last stage of working with these data, the authors presented their results to the mentors and the leaders of ENT3R. They responded that the results made sense in light of their experiences of ENT3R.

RESULTS AND DISCUSSION

What do the participants appreciate about ENT3R?

The first research question concerns what the participants perceive as being positive about ENT3R – the factors which make the students participate. When the participants share their experiences in the focus groups, their mentors are in focus: the mentors provide good teaching, create a positive atmosphere, engage in interpersonal relationships and are positive role models.

*The mentors provide good teaching*

Firstly, good teaching is impossible without content knowledge, and one boy expresses it like this: ‘It doesn’t help you to have a lot of humour, if you can’t do an $a^2 + a^3$.’ The participants appreciate how the mentors have solid content knowledge, being university students with good marks in higher level mathematics. They are impressed by mentors who ‘can answer everything’ and who ‘know many solving strategies.’ Furthermore, young persons’ enjoyment of hands-on activities is pointed to in recruitment literature (e.g., Swimmer & Jarratt-Ziemski, 2007; Woolston et al., 1997), and ENT3R participants confirm the importance of this. One of the girls reports that she has become more motivated to choose higher education in STEM, and explains it like this: ‘It’s largely because of how my mentors portrayed physics … used the tables, used rubber, threw stuff into the air, to show that physics is a subject with practical applications. Then physics suddenly became way more interesting.’

Secondly, some mentors are praised for their pedagogical skills and their ability to explain the subject matter in clear and understandable ways. A frequently used expression about the mentors is that ‘they explain well, so that we understand.’ The students also highlight mentors who combine teaching with humour. One of the boys says: ‘The thing is, I suppose, they teach us things in very fun ways, so you want to pay attention.’ In particular, the
students emphasise how the mentors give personal follow-up: the mentors highlight what is good in the students’ work, understand what the students need to know in order to make progress, and give hints instead of solving exercises for them. One of the boys describes it like this: ‘It’s not just he [the mentor] who solves the whole task for me. It is more like he solves the task in cooperation with me. And that gives you some self-confidence.’

Many school teachers obviously hold similar positive skills as those mentioned above, and the participants often compare ENT3R with the training they receive in school. There are, however, many differences between ENT3R and school contexts, which make such comparisons unreasonable. Most school teachers have a more complex group of students, including students who do not want to be there. Moreover, the mentors are not assessing the students’ performance and they are not committed to a curriculum, providing them with greater flexibility. With two mentors for approximately 10 students, they also have more time to guide each student than teachers have in school. It is, then, important that the ENT3R mentors seize this opportunity, like the mentors of this boy: ‘At school, they say that “Okay, we’re moving on! We have to finish the curriculum.” While here, it’s more like “Use the time you need, and we’ll help you until you understand.”’

Conclusively, like the good teachers in Norwegian schools, many ENT3R mentors also provide good teaching. One boy tells about his previous mentors. He struggled to learn any mathematics from these mentors, and this caused him to prioritise differently: ‘I was away from ENT3R quite a lot then.’ Other participants share similar stories. This illustrates how crucial it is for ENT3R that the mentors provide good teaching.

The mentors create a positive atmosphere

Many participants in ENT3R highlight how their mentors, through how they are and what they say, create a positive atmosphere. The maths trainings are informal and casual, and when participants suggest activities or need a break, this is usually well received. That is, the mentors are flexible and open, and one girl says: ‘Yes, it’s been good and educational and varied … We can decide much for ourselves, how the maths trainings should be. […] We can use them [the mentors] as we want, and that has been very positive.’ Moreover, through openness and honesty, the mentors have lowered the threshold for asking ‘stupid questions’ at the maths trainings. Several participants describe how they feel free to be open
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about their skills at the maths trainings, giving them confidence to ask the questions they need to ask, as this girl describes:

This is what makes people like me afraid to ask for help: I feel that the question is silly and that everyone else knows this, so I don’t dare to ask. But when I look at the mentors and can read from their body language that the question is not silly and that ‘I’ll help you no matter what you ask’, then at least I feel safe. I find it to be an important mentor characteristic that you can ask about anything. Nothing is too stupid.

These results are positive in light of Hattie’s (2009) work. After a comprehensive synthesis of more than 800 meta-analyses of educational research, he concluded that creating learning environments where failing is welcome as a part of the learning process and where everyone can feel safe, is among the main factors enhancing learning. Furthermore, Ashcraft (2002) describes how people with mathematics anxiety tend to avoid maths and miss out on many career paths. Thus, creating a learning environment where ‘stupid questions’ are allowed and where it is socially accepted to fail is of great importance.

Humour is a major element contributing to the atmosphere at the maths trainings. The participants highly value how the mentors integrate humour in maths presentations. One of the girls says that the mentor ‘sends a text message every week to remind me of ENT3R, and then he always adds some sort of maths joke.’ Even though not all mentors are humorous entertainers, their ability to whip up enthusiasm and be playful is described as an efficient way to lighten the mood. Some students even attend ENT3R mainly because ‘we have fun’, and this is held up as essential for this boy’s participation in ENT3R: ‘It mainly concerns that the person not only is someone that’s supposed to teach you, that you’re only there to learn. […] That you can joke around with the person and do other things, instead of having a kind of tense atmosphere.’

Another boy describes the project like this: ‘The best thing about ENT3R is that you can learn maths in a very social, fun and very informative milieu.’ The positive atmosphere, characterised by openness, safe learning conditions and humour, is created by the mentors of ENT3R in interaction with the participants. Holmegaard (2012) discusses how thoughts about the working life are involved in the complex process of choosing tertiary education.
Pleasant social experiences with STEM might lead the ENT3R participants to consider a STEM workplace as a place where they fit in socially.

The mentors engage in interpersonal relationships
A recurrent theme in the focus groups is that many participants view their mentors as friends. Some mentors take their participants out for ice-cream and some arrange playful competitions loosely related to STEM. The many descriptions of social activities and how ‘we can talk to them about anything’ indicate that many mentors have engaged in positive, interpersonal relationships with the participants. The STEM university students have become someone they know personally.

Some mentors are described as showing great belief in the participants’ abilities, and one boy says that ‘they sort of always believe in us. At least it seems like it.’ Several students describe how their mentors make them believe that they can master mathematics if they put an effort into it and keep practising. This insight is, according to Lyons (2006), highly important with regard to the choice of a STEM education. Lyons found that even the gifted students tend to worry about not mastering STEM. Girls in particular are worried about this, and rely heavily on people they know personally to build self-efficacy (Zeldin, Britner, & Pajares, 2008). On this basis, stories about encouraging mentors point to an important aspect of ENT3R. The participants have someone who knows them personally and who has competence in maths to help them build self-efficacy in this subject.

Not only are the mentors described as friends, but some are credited with great concern for the ENT3R participants: ‘The best thing about ENT3R is that the mentors show they care.’ Mentors who ‘never give up on you’ and are willing to spend leisure time making sure the participants are prepared for exams, have impressed the students. One boy describes how his mentors kept working with his particular maths problem at home. In the conversation that follows, three fellow participants all hold up the mentors’ engagement as very important for their participation in ENT3R. The boy concludes that ‘we feel they prioritise us above their own education.’

Furthermore, mentors’ reactions to students’ mastery experiences and improved marks are held up as the best memories of ENT3R by several participants. One boy expresses it like this: ‘I saw that my mentor was really happy.’ Jussim and Osgood (1989) found a strong link between individuals’ values and their perception of their friends’ values.
values mathematics achievements, you are more likely to value it yourself. Thus, considering that many participants regard their mentors as friends who care about their mathematics achievements, it might become more important for the participants to do well in mathematics.

The importance of the self-view when educational choices are made is elaborated on by Sjaastad (2011), who concludes that those who know youngsters personally are key persons in order to help them see themselves as future STEM students. Moreover, Buck and colleagues (2008) found that the young girls in their study viewed female scientists as their role models after they got to know them personally. Through friendships and by showing that they care for the students, the mentors are given the possibility of positively influencing the participants’ self-view with regard to STEM.

The mentors are positive role models

Even though the participants did not join ENT3R with the intention of meeting potential role models, the experiences described in the latter sections indicate that the mentors have, in fact, shown them new roles; ways to be a STEM student. The role model effect is highlighted in other out-of-school projects (e.g., Anderson-Rowland et al., 2005; Swimmer & Jarratt-Ziemski, 2007), where role models are described as helping the participants see themselves as future STEM practitioners, encouraging them into ‘thinking that they can be engineers too’ (Anderson-Rowland et al., 2005, p. 6). As discussed by Taconis and Kessels (2009), the existing stereotypes about people engaged in STEM constitute a potential barrier for young people considering a STEM education. According to the participants in ENT3R, their mentors have countered this stereotype, as this boy describes: ‘It might have changed my stereotypes. Like, if you pictured someone studying physics as having Einstein-hair and glasses, you would see that there are different people … A variety, not only the stereotype you imagine.’

Moreover, the mentors have impressed the participants in different ways, as elaborated on in the three latter success factors: the STEM students are clever, skilled and good communicators. They are open, playful and humorous, and they are nice, caring and attentive. In the focus groups, many students highlight that the mentors seem to enjoy what they study and ‘you are motivated to take the courses they do.’ The social life of a STEM student appears attractive to many participants, who share the impression that their mentors
have many good friends at the university. Also participants in other recruitment initiatives report appreciating insight into the life as a student at a university or university college (e.g., Swimmer & Jarratt-Ziems, 2007; Vollstedt & Wang, 2006). According to Illeris, Katznelson, Simonsen and Ulriksen (2002), young people want to be occupied with something they can throw themselves into – understood as something that can be a substantial part of their identity. The mentors in ENT3R, positively described in the focus groups, seem to have allowed the participants to meet nice people whose engagement in STEM is a substantial part of who they are. Being STEM role models, they have convinced several girls and boys that a sociable lifestyle might be an integral part of the STEM student role.

In what ways might ENT3R influence participants’ choice of education?

Before we proceed to discuss in what ways ENT3R might influence educational choices, we note that the participants were asked directly if ENT3R had influenced their plans for future education. The answers vary from no influence at all, to being decisive. Several say that they had originally planned to choose specialisation in language or social sciences in upper secondary school, but after joining ENT3R they have changed their plans and are now going to choose mathematics and natural sciences instead. Other students, who had already chosen specialisation in mathematics and natural sciences, claim that ENT3R has increased their interest in STEM careers. We do not know whether or not these ENT3R participants will actually go on to pursue a STEM career. We can, however, discuss whether the probability of a STEM-related educational choice is affected by ENT3R. In the following, we will look at how the five main components in Eccles and colleagues’ model might be positively affected by ENT3R, thus increasing the probability of future participation in STEM.

Expectation of success
The maths trainings in ENT3R strengthen the mathematical skills for several participants. They claim to have revised old techniques and learned new ones. Mathematics marks have improved for some. Many participants state that their self-confidence related to problem solving in general, and mathematics problems in particular, is heightened. Others say that ENT3R has made them more persistent; where they used to give up after only a few seconds, they now keep trying and dare to take on more difficult exercises, as this girl
claims: ‘You dare more here. When you work more with and understand stuff, you dare to meet challenges you normally wouldn’t have thought you could do.’

One girl shares how her mentors looked at her failed attempts to solve a problem, identified what was positive, and made her believe that she was heading in the right direction. A boy in the same focus group shares similar experiences about mentors who always make him believe that he has what it takes. The mentors use to tell him that ‘you just aren’t ready for it yet. Start here, and then you can move on. […] Nothing is impossible.’ Encouraging mentors have clearly heightened the expectation of success for many participants in ENT3R. Science education research points to the fact that maths and science are perceived as being more difficult than other subjects, and this is a reason young people give for not choosing these subjects (Lyons & Quinn, 2010). Among others, Bøe (2012) shows that girls in particular have a low expectation of success in maths and science. When ENT3R increases girls’ and boys’ abilities and self-confidence in STEM, they are left with fewer reasons for not choosing STEM in the future.

**Attainment value**

Attainment value is related to identity, and the mentors have increased participants’ attainment value in different ways. As discussed, the mentors’ willingness to engage in interpersonal relationships seems to have made it more personally important for some students to perform well in mathematics. The mentors have countered the participants’ stereotypes about the kind of people who choose STEM in higher education, and they have shown that the life as a STEM student might be sociable and pleasant. All these factors are assumed to improve the ‘fit to science culture’ (Taconis & Kessels, 2009) for the majority of young people. One girl initially thought that ‘all mathematicians and such were boring’, but she changed her view. So did this girl:

> Many people think [...] who wants to sit for seven years or so with the same topic, boring chemistry formulas, and such. But now it’s more like, you look up to that person. I would like to be like that, maybe.

Thus, the role model effect is evident in ENT3R. In Lyons and Quinn’s study, two out of three students that chose not to pursue science did so because ‘they could not picture themselves as a scientist’ (2010, p. 73). The participant’s quote above indicates that ENT3R
helps young persons to picture themselves as scientists, which according to Lyons and Quinn might increase the probability of a choice of STEM.

**Interest-enjoyment value**

Many participants say that ENT3R has provided them with enjoyable experiences related to STEM. Some appreciate the atmosphere, where they take part in maths activities in enjoyable and sociable ways. Others highlight presentations where humorous elements are integral parts. However, most stories shared in the focus groups about enjoyment of maths are stories of mastery experiences, as this boy describes: ‘I get kind of a feeling of victory. That is the major reason why I like maths, the feeling of victory. The feeling when I succeed in maths.’

Some participants talk about how new ways of looking at maths have increased their interest. This includes maths taught ‘differently from what you have in school’ and maths activities focused around problem solving, as opposed to merely calculations. When the participants share stories about how ENT3R has created interest in STEM, they often describe when they learned about the utility of STEM.

**Utility value**

Seeing the utility of STEM creates interest in the subjects, for instance, to see ‘how maths is used’ and how it ‘is connected to the practical, everyday life.’ Furthermore, the fact that STEM educations appear personally beneficial for many participants heightens the utility value they ascribe this choice. This holds even for those who do not want to become mathematicians, as this girl: ‘It’s not only a mathematician … and teacher you can become. Because that is what you initially think. But they [the mentors] study for careers in banks and to become financial counsellors, and different things like that.’

ENT3R has provided participants with information about different careers where mathematics is essential. One boy says that ‘it has helped me to find my way through kind of a jungle’, referring to the educational opportunities after secondary school. The career nights are highly appreciated by the participants. The contributors at these events represent companies the students can apply to with a STEM education, and they engage the participants in STEM activities related to their work. A girl says that ‘even though the lectures [at the career nights] aren’t always that fun, you learn and get to know how science can be applied.’ Many young girls and boys are strategic when they make educational
choices (Bøe, 2012), and they want to know how mathematics will help them reach goals they have set for themselves. The fact that these subjects provide career opportunities ‘has definitely strengthened my willingness to pursue a STEM education after secondary school’, one boy claims.

**Relative cost**

ENT3R has influenced how some participants perceive the costs related to a STEM education. Two kinds of statements support this. Firstly, statements related to the fear of failure indicate that ENT3R has changed their attitudes towards struggling with maths. One boy says: ‘When there are other young people here, struggling with the same things, you feel that you’re not the only one that doesn’t understand.’ Moreover, a common attitude promoted in ENT3R, mentioned by several participants, is that it is okay to struggle – you just have to keep working. Lowered anxiety related to problem solving lowers the perceived cost of engaging in STEM.

Secondly, some might believe that pursuing a STEM education means missing out on enjoyable years with sociable fellow students. For those who believe this, the perceived cost of choosing a STEM education is high. Statements indicate, however, that ENT3R has convinced many participants that studies in STEM are not like that: ‘It is very important … About the jokes and the light mood and … It’s not the formal setting as in school.’ In the focus groups, they highlight how studying STEM at the university seems sociable. The setting is informal with room for enjoyment, and you can find just as nice fellow students and colleagues in STEM as in any other education and career. By participating in ENT3R, many students might have realised that they do not have to give up a social life to pursue a STEM career.

**GENERAL DISCUSSION**

This study concerns a particular STEM mentoring project, namely the Norwegian ENT3R project. However, the discussion that follows provides knowledge that might be applicable to similar projects and by anyone who seeks deeper understanding of how persons influence attitudes and educational choices through recruitment efforts.

Having studied ENT3R at its most successful, drawing on focus group interviews with participants assumed to enjoy the project, four major factors that the participants appreciate
about ENT3R are identified here. These are all strongly related to the STEM university students employed as mentors: the mentors provide good teaching, are able to create a positive atmosphere, several mentors engage in interpersonal relationships and they are positive role models. We do not know for sure whether these experiences actually lead the youngsters to choose a STEM education. However, we have seen how all factors in Eccles and colleagues’ expectancy-value model are present when the participants in ENT3R share their experiences of the project. Thus, it is reasonable to assume that ENT3R strongly and positively influences its participants’ motivation for STEM educations and careers.

The factors identified here overlap with the pronounced aims of ENT3R presented in the beginning of this article; the possibility of succeeding in STEM is elaborated on, career opportunities are presented, and the participants are more likely to see themselves as scientists. However, the participants also emphasise positive aspects of ENT3R that are not stated as aims in the project description. For instance, they particularly value the mentors who engage in interpersonal relationships. This study suggests that the mentors who make friends with the participants are more efficient in supporting a choice of STEM. Secondly, some participants appreciate the maths training as a place where they can do maths without the distractions they have at home – such as Facebook and TV.

This study points to two important aspects of educational choices. Firstly, the complexity of educational choice is evident. Many students have reconsidered their educational plans due to ENT3R, but they highlight different reasons for these shifts. The variety of experiences in ENT3R shared in the focus groups indicates that ENT3R works in many ways. This is a great strength, considering the individual differences among the youngsters: throughout the educational choice process, students varyingly weight the importance of factors like mastery experiences, knowledge about careers and insight into the student life. Either way, ENT3R provides experiences relevant to most students’ current situations. Secondly, the educational choice process is, indeed, a process. Educational choices might develop over years up to the moment when youngsters submit their applications for upper secondary and tertiary education. Participants in ENT3R described how they over time had come to believe in their own abilities, had come to know the mentors as nice STEM students, and had realised the utility and joy of STEM subjects. Holmegaard (2012) looks at the narratives young people create concerning their educational choices. Over years, the youngster tells and retells the story of the educational choice until it is accepted as plausible by both the individual and his
or her surroundings. In ENT3R, the students might participate for up to four years, and many mentors in ENT3R engage in interpersonal relationships with the participants. These might thus be important sparring partners for the participants as they develop narratives about their educational choice.

**The role of out-of-school projects**

As many mentors do in ENT3R, many school teachers also provide good teaching. They too engage in interpersonal relationships, create a positive atmosphere in the classroom and are positive role models. This fact calls for a discussion about the role out-of-school projects should play in the collection of efforts for STEM recruitment. Could we just as well spend the resources on teacher education and improve mathematics and science education in school?

School science is a highly important factor influencing adolescents’ relationship to STEM and therefore also the recruitment to STEM careers (Lyons, 2006). However, projects like ENT3R might still play an important role due to the fact that it intersects school and leisure: on one side it has a lot in common with school lessons. On the other side, the project is consciously profiled as something other than school, in ways appreciated by many participants: the mentors in ENT3R have more time for each student, there are no tests or set curriculum, and the participants might strongly influence what happens at the maths trainings – opening up for a greater share of games, riddles and other fun activities.

Moreover, ENT3R heightens the total exposure of these subjects for its participants. Simpkins, Davis-Kean and Eccles (2006) found that students who engaged frequently in maths and science activities in 5th grade were more likely to have a higher self-concept in maths, become more interested in the subject, and put more importance on maths and science skills at a later stage. Based on results from several large national and international surveys, Bøe, Henriksen, Lyons and Schreiner (2011) argue that disenchantment with science is mainly related to school science, as opposed to science in general. Intersecting school and leisure, projects like ENT3R are in a unique position to show young people that the popular science they enjoy has a lot in common with the school science some might be disenchanted with.
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Implications for recruitment initiatives

This study illustrates that the educational choice is a complex process. Thus, a recruitment initiative benefits from offering a variety of experiences. Initiatives drawing on only one feature might not be relevant for the majority of participants. The participants should be offered a spectrum of experiences, influencing both their self-perceptions and their perceptions of STEM subjects, careers and practitioners. Moreover, allowing participants to engage in a project over time makes it possible to support the youngsters through the process of their educational choice.

This study suggests that ENT3R is a success. It is, then, important to note that the project is based on experiences from other projects and has been evaluated and adjusted over the last five years. Bischoff, Castendyk, Gallagher, Schaumloffel and Labroo (2008) argue that their summer camp recruitment initiative would not have been as successful if it had not existed for several years and undergone evaluations and improvements. Thus, anyone initiating such projects should include evaluations in their project descriptions and be willing to make adjustments according to these.

The most prominent implication of this study regards the executors of the project: it is essential to carefully select those who will meet the young people personally. This is obvious in the case of ENT3R, being a mentoring project. However, the factors identified in this article as for why the participants enjoy ENT3R might point to important qualities and qualifications for other persons involved in young people’s educational choice processes: Do they have pedagogical skills and content knowledge? Are they able to create a positive atmosphere and engage in interpersonal relationships? Are they positive role models? In ENT3R, these qualities and qualifications are ensured through a thorough application process and mentor training.

Conclusively, a recruitment project benefits from involving several and diverse activities, interacting with youngsters over an extended period of time, and it should involve personal meetings between youngsters and positive STEM role models. These are all factors that might positively influence youngsters’ motivation for STEM educations and careers.
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Measuring the Ways Significant Persons Influence Attitudes Towards Science and Mathematics

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Young people’s attitudes towards science, technology, engineering, and mathematics (STEM) are subject to interpersonal influence of significant persons—defined as those who influence a person’s attitudes. This article presents the development of an instrument designed to measure different modes of significant persons’ influence on attitudes towards STEM. The questionnaire used in the pilot study was compiled based on Woelfel and Haller’s theoretical perspectives on interpersonal influence, Nauta and Kokaly’s instrument Influence of Others on Academic and Career Decisions Scale, and focus group interviews with Norwegian adolescents in an STEM mentoring programme. Drawing on Rasch analyses of data material from the 114 participants in the pilot study, the final instrument—Significant Person Influence on Attitudes towards STEM (SPIAS)—is presented. Based on results from the piloting and development of SPIAS, a conceptual discussion of significant persons and the ways they influence attitudes towards STEM is given, and it is suggested that SPIAS may be used in the process of evaluating and improving interventions aimed at changing adolescents’ attitudes towards STEM.

Keywords: Significant persons; Attitudes; Recruitment; Mentoring; Rasch analysis

Introduction

In recent years, policy makers, industry, and science educators have initiated interventions to increase the number of young girls and boys choosing educations within science, technology, engineering, and mathematics (STEM) in order to meet the increased demand for persons with STEM competence (e.g. EU, 2004; Osborne & Dillon, 2008; Stine & Matthews, 2009). Most attempts to change attitudes towards STEM...
STEM involve persons; parents, teachers, celebrities, or most commonly the persons administering the intervention.

Throughout the last four decades, attitudes towards STEM have been thoroughly investigated (e.g. Gardner, 1975; Osborne, Simon, & Collins, 2003; Osborne, Simon, & Tytler, 2009). Due to the current challenges in recruitment to STEM, attitudes continue to be subject to science education research (e.g. Bennett & Hogarth, 2009; Sjøberg & Schreiner, 2010). The important role of other persons in young people’s attitudes towards and choice of STEM is a returning theme (e.g. Aschbacher, Li, & Roth, 2010; Cleaves, 2005; Sjaastad, 2011). In particular, the role of teachers (e.g. den Brok, Fisher, & Scott, 2005; Carrington, Tymms, & Merrell, 2008) and parents (e.g. Adamuti-Trache & Andres, 2008; Dryler, 1998) has received attention.

A wealth of instruments have been developed to measure attitudes towards STEM (e.g. Hong & Lin, 2010; Kind, Jones, & Barmby, 2007) and STEM aspirations (e.g. DeWitt et al., 2011). Blalock et al. (2008) reviewed 66 such instruments and concluded that attitude researchers keep re-inventing the wheel, inventing ‘measures strikingly similar to previously published ones’ (p. 972). Moreover, they found that most instruments were presented without documentation of important psychometric properties. Increased attention to the psychometric properties of such instruments has led science education researchers to propose using item response theory, and in particular Rasch theory, in developing such instruments (Boone & Scantlebury, 2006; Boone, Townsend, & Staver, 2011). Examples of use in science education include research on attitudes towards STEM (Zain, Samsudin, Rohandi, & Jusoh, 2010), an analysis of a nature of science test (Neumann, Neumann, & Nehm, 2010), and an investigation of mathematics teachers’ opinions on teacher practices (Grimbeek & Nisbet, 2006).

When STEM recruitment initiatives are evaluated, it is obviously important to measure attitude change. However, missing in the wealth of attitude instruments are those designed to measure in what ways significant persons influence attitudes towards STEM. Complying with Blalock et al. (2008) critique, the author has attempted to create such an instrument drawing on an existing one, and the Rasch model is utilised to investigate its psychometric properties. That is

The main purpose of this article is to describe the development and validation of an instrument measuring different modes of significant persons’ influence on adolescents’ attitudes towards science, technology, engineering, and mathematics.

The existing instrument to be utilised is Nauta and Kokaly’s (2001) ‘Influence of Others on Academic and Career Decisions Scale’ (IOACDS). Having developed the IOACDS, Nauta and Kokaly concluded that ‘persons perceived as role models may be able to facilitate academic and career development via their support and guidance as well as via the degree to which they provide inspiration and modelling’ (Nauta & Kokaly, 2001, p. 95). All these aspects are included when Woelfel and Haller (1971) describe the influence of significant persons. Thus, Woelfel and Haller will provide the theoretical framework for the development of Significant Person Influence on Attitudes towards STEM (SPIAS), which is presented in this article.
Theory

In the late 1960s and early 1970s, social psychologists Joseph Woelfel and Archibald O. Haller investigated interpersonal influence. They stated that ‘significant others are those persons who exercise major influence over the attitudes of individuals’ (Woelfel & Haller, 1971, p. 75). Two comments should be made about this anticipatory definition. First, the phrase ‘significant other’ is used in some contexts to describe a romantic partner. Thus, the phrase ‘significant person’ will be used throughout this article to avoid confusion. Second, the significant persons are defined in terms of their influence over attitudes, making it important to note how attitudes are defined by Woelfel and Haller. The following paragraphs are based on four articles (Haller & Woelfel, 1972; Woelfel, 1968, 1972; Woelfel & Haller, 1971).

According to Woelfel and Haller, an attitude is dependent upon the relationship between two components: The individual’s conception of his self and the individual’s conception of the object towards which the attitude is aimed. Note that it is the conceptions that form the attitude. ‘This is not meant as a denial of the reality of objects apart from individual’s conceptions of them’ (Woelfel, 1968, p. 5), but it merely points to the fact that it is how the individual perceives his self and the object—not how they actually are—which influences how he relates these. Conclusively, Woelfel and Haller view an attitude as a person’s conception of relatedness between his conception of his self and his conception of the object.

A sentence like ‘science takes hard work’ is not an attitude according to this definition; it is merely a statement about the object. The person’s conception of his or her self must be included: Sarah and Susan might both agree to this statement and still have different attitudes towards science due to how they perceive themselves. Sarah, who considers herself as being too laid-back for hard work, might have negative attitudes towards science. Susan, on the other hand, considers herself as someone who enjoys a challenge, and has positive attitudes towards science based on the same statement.

Woelfel and Haller define significant persons using slightly different wording in the four articles. Drawing on these, a significant person is defined here as a person who either through direct interaction or by example provides information which influences the focal individual’s conception of his or her self or the focal individual’s conception of an object. ‘An object’ may for instance be mathematics, a set of STEM related careers, the physics class, or scientists. The information provided may be insufficient and even incorrect, but as long as it is integrated in the individual’s conception, the influence is present.

According to this definition, a significant person is someone who influences one or both of the elements of attitudes, namely the conception of one’s self and the conception of the attitude object. Moreover, the definition states two ways for significant persons to exercise such influence, namely through direct interaction and by providing examples. Those who provide information through direct interaction are called definers. Definers most commonly use words to ‘communicate norms, expectations, or other self- or object-defining information to an individual’ (Haller & Woelfel, 1972,
Those who by example provide information influencing attitudes are called models. Models are observed by the individual and they ‘stand as points of cognitive reference but do not [necessarily] interact with the subject’ (Haller & Woelfel, 1972, p. 594). Thus, conceptually, there are four ways to exercise ‘significant person influence’. These are displayed in Figure 1 as a diagram to emphasise that there are no strict boundaries between the four modes of influence.

- **Defining the self**: Providing attitude-relevant information about the focal individual’s self through direct interaction.
- **Defining the object**: Providing information about the attitude object through direct interaction.
- **Modelling a self**: Providing an example of a self in relation to the attitude object.
- **Modelling the object**: Providing an example of the attitude object.

A science teacher may exemplify all four modes of significant person influence: One student believes she has the ability to study science due to this teacher’s encouragement (defining the self), while another student remembers what the teacher told about career opportunities for those who study science (defining the object). Having gotten to know the teacher, a third student has realised that science people are just as nice and outgoing as everyone else (modelling a self), and a forth student is inspired by the exciting presentations given by this teacher in science class (modelling the object). These four modes of influence will be the starting point for the development of SPIAS.

**Methods**

**Drawing on Nauta and Kokaly’s Work**

Blalock et al. (2008) argue that new instruments should be developed from existing ones. Thus, to draw methodological inferences from an existing instrument, Nauta and Kokaly’s (2001) instrument will be reviewed here in the Methods section. IOACDS was developed by Nauta and Kokaly in order to ‘determine the dimensions of role model influence’ (Nauta & Kokaly, 2001, p. 84). College students were invited
to write about their role models, and these responses gave rise to five categories to which Nauta and Kokaly created questionnaire items. The respondents in the pilot study marked off on a five-point Likert scale from ‘Strongly disagree’ to ‘Strongly agree’ to statements like ‘In the academic or career path I am pursuing, there is someone I admire’ and ‘There is no one who gives me academic and career advice’. Factor analysis of the data material returned two main factors consisting of the items given in Appendix 1, namely, an ‘inspiration/modelling’ and a ‘support/guidance’ factor. The final version of IOACDS was validated in several ways, e.g. by assessing its relationship to different scales measuring career decisions and social support.

Reassessing the psychometric properties of IOACDS using Rasch analysis, which will be introduced in the forthcoming paragraph, confirms that IOACDS works as intended. Data indicate that the two factors are different from each other, and no subdimensions are present in the factors. Drawing on this development, SPIAS will be developed similarly, drawing on focus groups interviews and utilising Likert scale items. Furthermore, Nauta and Kokaly state: ‘We do not suggest that providing support and guidance should be included as defining characteristics of role models; however, these results suggest the importance of recognising that persons perceived as role models may be able to facilitate academic and career development via their support and guidance as well as via the degree to which they provide inspiration and modelling’ (Nauta & Kokaly, 2001, p. 95). A further development of IOACDS should thus draw on a framework including all these modes of influence. The framework of Woelfel and Haller is appropriate in this case, defining significant persons both in terms of support and guidance (definers) and in terms of inspiration and modelling (models).

**Rasch Analysis**

In short, Rasch analysis (Rasch, 1960) pursues the idea that a test should measure one trait only, indicated by ‘unidimensional’ data. Persons with different amounts of the trait have different probabilities of responding in different response categories, and this is mathematically expressed in the Rasch model. In a Rasch analysis the response patterns are examined mathematically, and major deviations from the expected patterns indicate that data might not be unidimensional.

The instrument developed here is a questionnaire with selected response items, where the participants respond to statements using a graded scale. The responses to particular sets of items are combined to form scales in order to measure four ways of being a significant person. This requires that (1) the measures are represented by values on a scale with a constant unit (an interval scale) and (2) dimensionality issues become important when seeking to measure four different modes of significant person influence (Gardner, 1996). The Rasch model is a mathematical model for measurement which provides ways to test for unidimensionality (Tennant & Pallant, 2006), and it locates persons and items on an interval scale with equal-sized steps (‘logits’). The model was originally developed for dichotomously scored
items, but has been generalised to partial credit and Likert scale items, as used in many attitude instruments. Thus, it supports the development of an invariant measure where persons with the same amount of a latent trait have the same probability of responding in different categories (Hagquist & Andrich, 2004).

The Rasch model is probabilistic, meaning that it gives the probability of a person endorsing an item based on the difference between the persons’ and the items’ location (Loc) on the logit scale (Andrich, 1988). Usually, the scale is normalised making the mean item location equal to zero. A high item location means that much of the latent trait is needed to have a high probability of endorsing the item, and correspondingly, an increase in person location indicates an increase in the amount of the latent trait. Mathematically, the Rasch model is expressed by a logistic function represented by the item characteristic curve (ICC) shown in Figure 2a. An item’s fit to the model is inspected by looking at the deviations of the observed group values (the dots in Figure 2a) from the logistic function (Styles & Andrich, 1993). In this article, item fit is calculated by taking the standardised sum of all differences between observed and expected values summed over all persons. Values greater than $+2.5$ indicate that the item under-discriminates (Figure 2b), while values below $-2.5$ indicate that the item over-discriminates (Figure 2c).

The Rasch model also has other properties useful for the development of SPIAS: (1) The person separation index (PSI), equivalent to Cronbach’s alpha in many ways, indicates if the test is well targeted (Tennant & Conaghan, 2007), that is, if the set of items fits the group of persons taking the test. The PSI is used to investigate ‘the replicability of person ordering’ (Bond & Fox, 2007, p. 40). (2) To ensure that the distance between two specific response categories is held constant for all items in the instrument (e.g. the distance between categories ‘1’ and ‘2’ are equal for all items), a model with fixed thresholds is necessary: thresholds are the points on the logit scale.

![Figure 2. ICC with (a) observed group values, well functioning item, (b) observed group values, under-discriminating item, (c) observed group values, over-discriminating item, (d) observed group values, item showing uniform DIF](image)

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where the probabilities of endorsing two successive categories are equal. Thus, an
item with four ordered response categories has three thresholds (Thr) to be estimated
in the analysis. Thresholds are held fixed in the rating scale model (Wright & Masters,
1982). (3) Instances of differential item functioning (DIF), where the invariance
property is violated, can be revealed. When the respondents are grouped according
to selected properties, e.g. age, social background, or gender as in this article,
persons from different groups with the same location on the logit scale are supposed
to have the same probability of endorsing a response category. An example of a DIF
analysis showing uniform DIF is given in Figure 2d. (4) Unidimensionality can be
investigated by letting the person-by-item residuals undergo a principal component
analysis (PCA). If a $t$-test shows that about 5% or more of the respondents score
significantly different on the subdimensions suggested by the principal components,
the construct measure may be compromised by other dimensions and should be
investigated further (Tennant & Conaghan, 2007).

Standard analyses could have provided properties equivalent to several of the Rasch
properties mentioned here. However, Rasch analysis is developed with a particular
focus on dimensionality issues, which is important here, trying to measure four
slightly different dimensions of significant person influence. Due to this and the prop-
erties mentioned above, Rasch theory applied to a rating scale model will be applied in
developing SPIAS. The analyses will be conducted using Rasch analysis software
RUMM 2030 (Andrich, Lyne, Sheridan, & Luo, 2003). SPIAS will consist of four
construct measures, each attempting to measure a specific construct. A construct
can be understood as ‘some postulated attribute of people, assumed to be reflected
in test performance’ (Cronbach & Meehl, 1955, p. 283). In this case, the four con-
structs are four different modes of significant person influence.

Focus Groups and Target Group for the Pilot Study

According to Suyono, Piet, Stirling, and Ross (1981) results from focus groups ‘are
qualitative in that they indicate the breadth of attitudes that exist on a topic rather
than quantifying them’ (p. 434). Therefore, focus groups can be utilised to generate
ideas for questionnaire items. The focus group participants in this study were chosen
from the target group of the pilot study, namely, participants in the mentoring pro-
gramme ENT3R.

ENT3R is a Norwegian project initiated to heighten recruitment to STEM (The
RENADE Centre, 2011). Teenagers come to their local university or university
college once a week for maths training and STEM-related activities provided by
STEM students. Sjaastad and Jensen (2011) investigated ENT3R and highlight
that the mentors offer the participants a variety of experiences and that they engage
in interpersonal relationships with the participants. Thus, these participants probably
have experiences enabling them to answer questions about SPIAS. Note the theoreti-
cal importance of having the adolescents themselves as a target group for SPIAS. In
order to investigate what a significant person has done to influence attitudes, the sig-
nificant person could tell what he or she has done. Woelfel and Haller’s definition of
attitudes suggests why this is inadequate: the ENT3R participants’ attitudes towards STEM are not changed based on what the mentors actually do or how the mentors actually are, but based on how the participants perceive these actions and persons.

Three focus group interviews were conducted with ENT3R participants, following the methodological guidelines of Morgan and Krueger (1998). Twelve girls and five boys from 16 to 18 years old took part in these, discussing in what ways the mentors had influenced their relationship to STEM. These discussions were audio-recorded, transcribed, and coded by the author according to the framework of Woelfel and Haller.

**SPIAS Item Development**

In creating the questionnaire items, words and phrases that appeared frequently in the focus groups were used, for instance ‘new sides of maths’, ‘what the mentors are like as persons’, and ‘how much I am able to do in maths’. The main questions were worded ‘To which extent have you experienced that your mentors have done the following?’ and ‘To which extent do the following statements apply?’ A Likert scale was used with boxes labelled ‘1 (small extent)’, ‘2’, ‘3’, and ‘4 (large extent)’. Four categories were chosen to avoid a neutral mid category being used as an ‘I do not know’ or ‘I do not care’ response (Kulas, Stachowski, & Haynes, 2008). With only about 100 respondents in the pilot study, six categories could have led to many instances of unused categories.

The terms ‘maths’ and ‘STEM’ are used in the questionnaire. Questions about what respondents actually do in maths training and how this helps them progress in the subject are worded ‘maths’. Questions specifically about the mentors and questions about the educational choices are worded ‘STEM’; the mentors are STEM students, they talk about STEM educations, and give examples from STEM careers, and the overall aim in the ENT3R project is recruitment to STEM. The acronym ‘STEM’ was not used in the Norwegian version of the questionnaire. The word ‘realfag’ was used, and the content of this word is commonly understood as STEM. The fact that the pilot study was conducted in a language other than English must be noted. All psychometric properties presented in this article relate to the Norwegian version of SPIAS. However, the translation of SPIAS has been discussed with native English speakers, which arguably makes it likely that items would be understood in a similar manner by an English-speaking language group as they were by the Norwegian respondents.

When using items to tap into a construct, it has to be considered how different the items should be. The items have to be about ‘the same thing’ but should also not be too similar; they must represent the breadth of the construct. Six items were created for each of the four construct measures, and quotes from the focus groups were used to phrase each of these 24 items. Seven items were included in addition to these. Three of these were ‘bonus items’ to the ‘Defining the self’ construct measure (items 3A, 5E, and 5G, Appendix 2). They do not draw on quotes from the focus groups, but are still closely related to the construct and concern self-knowledge gained through interaction with the mentors. For instance, item 5E is about
whether the mentors have contributed so that ‘I have discovered my abilities in maths’. This is perhaps not something a participant would say in a focus group, but it is still relevant for the construct. Four ‘between-constructs items’ were created out of theoretical interest, tapping into two constructs at the same time. Including these in the analyses might indicate the precision of the instrument. The questionnaire items were arranged in the questionnaire not according to the constructs, but according to which of the two question headings the items naturally belonged to (“To which extent have you experienced that your mentors have done the following?” and “To which extent do the following statements apply?”). Within the question headings, items were mixed randomly.

In the pilot version of SPIAS, three questions were included about gender, change in the relationship to mathematics due to ENT3R, and change in the probability of choosing an STEM education due to ENT3R. Finally, the respondents were given the following opportunity: ‘Is there anything you want to comment on?’ followed by three open lines. The pilot version of SPIAS was discussed thoroughly with experienced colleagues before conducting the pilot study, and it is given in Appendix 2.

A comparison between the pilot version of SPIAS and Nauta and Kokaly’s instrument IOACDS, upon which the development of SPIAS is partly based, reveals that the following steps have been taken: (1) The five-point Likert scale is reduced to a four-point Likert scale to avoid the neutral mid-category. (2) The IOACDS measures two constructs: support/guidance and inspiration/modelling. These are refined to four constructs according to Woelfel and Haller’s framework. (3) The 15 items in IOACDS are extended to 31 items for the pilot version of SPIAS; e.g. items 9 and 10 in IOACDS overlap in content with items 3D, 3G, 3I, and 5F in SPIAS. The somewhat different definitions of the constructs and the use of focus group participants’ quotes made the wording of items different than the parallel items in IOACDS.

**Pilot Study**

The questionnaire was administered on paper to 69 girls and 45 boys from 15 to 19 years old, and these 114 participants represent four different branches of ENT3R, based at the universities in Oslo, Trondheim, and Bergen, and the university college in Bergen. Data were collected during ENT3R maths trainings in late April and early May 2011. On five occasions, immediately after a group of participants had responded to the questionnaire, two to three respondents were invited to take part in a discussion concerning the questionnaire. They were asked about their thoughts concerning the questionnaire in general, if any items were strange or difficult to understand, if there were important aspects of the mentors not covered by any item, and their thoughts on the response scale. These conversations provided valuable information, which will be discussed in the Results section.

**Developing the Four Construct Measures for the Final Version of SPIAS**

The final version of SPIAS contains four construct measures corresponding to four modes of significant person influence. Having conducted the pilot study, Rasch
analysis was utilised to support the development of the four construct measures. That is, the 31 items were reduced to four collections of 4–5 items constituting the four construct measures. For each of these, the analyses and item removal processes were conducted as follows: (1) An analysis with the six original items belonging to the construct was conducted. Items with poor psychometric properties (poor item fit, gender DIF, etc.) were evaluated as candidates for removal, and a second analysis was conducted without these. (2) Of theoretical interest, the two ‘between-constructs items’ tapping into the construct were analysed together with the items left after the previous analysis. (3) For each new analysis, drawing on psychometric properties, the author’s interpretation of the construct, and identification of redundant items, new candidates for removal were identified and new analyses conducted without these. (4) Finally, an analysis without any misfitting items was conducted, and the final version of the construct measure was decided upon.

This instrument was developed to measure in what ways the mentors in ENT3R have influenced the participants’ attitudes towards STEM. In the pilot version of SPIAS, however, several items were included which are considered redundant or not sufficiently relevant for a mentoring programme context. These were removed during the analyses, but were included in the pilot study to give suggestions for well-functioning items when SPIAS is applied to other contexts.

Results

Questionnaire Discussions

A main topic in the five conversations with respondents concerning the questionnaire was ‘repetitiveness’. Many items were similar, and all the five groups claimed that the questionnaire could benefit from being shorter. One particular item was mentioned by three groups as being strange: [The mentors have] ‘Talked about who can master STEM’ (item 4A). They were satisfied with the response categories, although someone mentioned that they missed a neutral mid-category. Together with the forthcoming results from the Rasch analyses, these discussions provided information about how to revise and shorten the instrument. In particular, the reported repetitiveness encouraged the author to look for redundant items.

Developing the ‘Defining the Self’ Construct Measure

The ‘Defining the self’ construct measure had six original items, two between-constructs items (items 3D and 4A), and three bonus items created without using quotes from the focus groups (items 3A, 5E, and 5G). The four items in bold constitute the final version of the construct measure (Table 1).

Seven analyses were conducted to develop this construct measure. Most items were removed due to redundancies, e.g. item 5C regarding ‘how much I am able to do in maths’ had poor fit to the Rasch model and was partly covered by items 3C and 3F. Having removed two of the six original items, the two between-constructs items were
included. They were both removed (item 4A due to feedback in the discussions with respondents who had completed the questionnaire), and the three bonus items were finally included. Three additional analyses were conducted, where one item was removed for each analysis. The last item to be removed was item 3J (‘The mentors have been important for my belief that I will reach the goals I set for myself in maths’). This item is about skills, as are items 3C, 3F, and 5E in slightly different ways. Seeking to shorten the instrument, item 3J was removed being considered to have the poorest wording. Four items are left representing the ‘Defining the self’ construct well. The psychometric properties are good and they are shown in the first column of Table 2.

One item in the ‘Defining the self’ construct measure is about the individual’s enjoyment of maths and three items are about mathematics skills: Self-confidence,

<table>
<thead>
<tr>
<th>Table 2. Psychometric properties of the final construct measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining the self</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td><strong>PSI</strong>: 0.72</td>
</tr>
<tr>
<td><strong>PCA</strong>: OK</td>
</tr>
<tr>
<td><strong>Thr</strong>: OK</td>
</tr>
<tr>
<td><strong>DIF</strong>: OK</td>
</tr>
<tr>
<td>Item</td>
</tr>
<tr>
<td>3C</td>
</tr>
<tr>
<td>3F</td>
</tr>
<tr>
<td>3H</td>
</tr>
<tr>
<td>5E</td>
</tr>
<tr>
<td>5G</td>
</tr>
<tr>
<td>5A</td>
</tr>
</tbody>
</table>
understanding, and abilities. Other aspects of a person’s self-view that influence attitudes towards STEM which may be included when applying SPIAS in other contexts may be more general characteristics like being hard-working, being intelligent, and ‘coming from a family with STEM traditions’.

Developing the ‘Defining the Object’ Construct Measure

The ‘Defining the object’ construct is about what the mentors have said about STEM with regard to education, careers, utility, etc. In addition to the six original items, two between-constructs items (items 3B and 4A) were included in the analyses. The four items in bold constitute the final version of the construct measure (Table 3).

Four analyses were conducted with combinations of these items. Concerning the two between-constructs items, item 3B was removed due to poor psychometric properties (fit residual of +2.6) and item 4A due to the responses in the discussions with participants about the questionnaire. Items 2C and 4D were considered redundant: The former concerns reasons for continuing to choose STEM and is covered by items 2A and 4C, while the latter concerns STEM studies and is covered by item 2E.

Four items now constitute the ‘Defining the object’ construct measure, with psychometric properties shown in the second column of Table 2. Two items are about STEM education and careers, and two items are more general, about ‘what I can use STEM for’ and ‘the role of STEM in society’. SPIAS applied to other contexts may for instance include items regarding persons talking about the philosophical underpinnings and the historical development of these subjects.

Developing the ‘Modelling a Self’ Construct Measure

The ‘Modelling a self’ construct measure had six original items and two between-constructs items (items 2F and 3D). The four items in bold constitute the final version of the construct measure (Table 4).

Five analyses were conducted in developing this construct measure. Again, most items were removed due to redundancies: Item 3E is covered by 5A, and items 5D and 5F are covered by items 3G and 3I. In the third column of Table 2, the

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>[The mentors have] Talked about careers I can get with an education in STEM</td>
</tr>
<tr>
<td>2C</td>
<td>[The mentors have] Talked about why I should continue choosing STEM</td>
</tr>
<tr>
<td>2E</td>
<td>[The mentors have] Talked about different studies I can take in STEM</td>
</tr>
<tr>
<td>3B</td>
<td>Through my mentors I have learned more about maths (between-constructs item, between ‘Defining the object’ and ‘Modelling the object’)</td>
</tr>
<tr>
<td>4A</td>
<td>[The mentors have] Talked about who can master STEM (between-constructs item, between ‘Defining the object’ and ‘Defining the self’)</td>
</tr>
<tr>
<td>4C</td>
<td>[The mentors have] Talked about what I can use STEM for</td>
</tr>
<tr>
<td>4D</td>
<td>[The mentors have] Talked about STEM studies at university</td>
</tr>
<tr>
<td>4F</td>
<td>[The mentors have] Talked about the role of STEM in society</td>
</tr>
</tbody>
</table>
psychometric properties of the final four items are given. This time, an exception was made concerning one of the two between-constructs items; ‘The mentors have shown me whether it fits me to be an STEM student’ (item 3D). This is included in the final construct measure, even though it was initially meant to tap into both ‘Modelling a self’ and ‘Defining the self’ and created mostly out of theoretical interest. In hindsight, this item suits the former construct well both in terms of psychometric measures and in terms of content. The wording is close to the common conception of role models, and thus the item makes a positive contribution to the construct measure.

The ‘Modelling a self’ construct is the mode of significant person influence closest to what is often recognised as role models; ‘inspiring and motivating them to do their utmost best’ (Lockwood & Kunda, 1997, p. 91). Notably, the items in this construct measure open up for negative and neutral role models. E.g. having ‘an impression of what the mentors are like as persons’ (item 3G) does not necessarily mean a positive impression.

Developing the ‘Modelling the Object’ Construct Measure

The final construct measure to be developed was ‘Modelling the object’. The six original items and the two between-constructs items (items 2F and 3B) were analysed, and the five items in bold constitute the final version of the construct measure (Table 5).

Three analyses were conducted with combinations of these items. In addition to the between-constructs items, item 2G was removed. This item is redundant due to items 2B, 4B, and 4G. Thus, five items constitute the construct measure, and the psychometric properties are shown in the fourth column of Table 2. The PSI of 0.58 is low, but acceptable (Cronbach’s alpha = 0.7).

A significant person modelling an object provides the focal individual with an experience of the object or is observed by the individual doing object related activities. The five SPIAS items included in the final construct measure concern showing new perspectives on maths, maths related examples, and new solving strategies. Traditional teaching obviously taps into this construct, as do arranging for the focal

| 2F [The mentors have] Shown what people with an STEM education do at work (between-constructs item, between ‘Modelling a self’ and ‘Modelling the object’) |
| 3D The mentors have shown me whether it fits me to be an STEM student (between-constructs item, between ‘Modelling a self’ and ‘Defining the self’) |
| 3E I have an impression of what the mentors think about their studies |
| 3G I have an impression of what the mentors are like as persons |
| 3I The mentors have shown me examples of what kind of qualities STEM students can have |
| 5A I have an impression of how the mentors experience their studies |
| 5D I feel that I know my mentors |
| 5F The mentors have shown me how STEM students can be |
individual to engage in hands-on activities related to the object—thus including the significant persons that do not participate in the activities themselves.

Summary of Results

The 31 items in the SPIAS pilot questionnaire are now reduced to 17 items, measuring four different ways for significant persons to influence attitudes towards STEM. SPIAS holds good psychometric properties, as shown in Table 2, and the content of the four construct measures relate strongly to the constructs as they are defined by Woelfel and Haller (Haller & Woelfel, 1972; Woelfel, 1968, 1972; Woelfel & Haller, 1971). There will always be gradual transitions between constructs and sub-constructs. For instance, some would consider ‘abilities in algebra’ as a construct, while others would consider it as a subconstruct belonging to the ‘abilities in maths’ construct. The four construct measures developed here could be considered as subconstructs belonging to a general ‘significant person influence’ construct. Considering all 17 items as constituting such a construct measure, a PCA analysis indicates how the different subconstructs relate to each other. The items’ loadings to the first and second principal component (PC1 and PC2, respectively) provided by such an analysis are visualised as suggested by Olsen, Garratt, Iversen, and Bjertnaes (2010) in Figure 3. PC1 accounts for 20% of the variance in the residual data matrix, and a t-test shows that 21% of the students answer significantly differently on the items grouped according to this component. PC2 accounts for 14% of the variance, and 11% of the respondents answer significantly differently on this grouping of items. Note that the first principal component groups the items from the ‘Modelling the object’ and ‘Defining the self’ construct measures, while the ‘Modelling a self’ items are grouped with the ‘Defining the object’ items. Furthermore, PC1 and PC2 taken together indicate a strong relationship between the two latter construct measures. These results will be commented on in the discussion.

Discussion

Drawing on the development of SPIAS, we now turn to a conceptual discussion concerning significant persons. Woelfel and Haller (1971) created a theoretical
framework where significant persons are defined in terms of four different ways to influence attitudes. Two dualities create the four modes of significant person influence: The focus of the communication; self and object, and the ways of communicating information about these; defining and modelling. The PCA of all 17 items belonging to the four constructs measures indicates that there is a link between the ‘Defining the self’ and ‘Modelling the object’ construct measures, and an even stronger link between the ‘Defining the object’ and ‘Modelling a self’ construct measures (Figure 3). Unexpectedly, these were not grouped according to whether they were defining/modelling or self/object construct measures. This may provide us with a ‘third duality’ related to significant person influence.

Defining the self and modelling the object can be said to be about ‘my STEM self-concept and my experiences with STEM’. Likewise, modelling a self and defining the object can be said to be about ‘what STEM persons are like and what they are occupied with’. In short, the former is introspective while the latter is extrospective. The particularly close connection between the ‘Defining the object’ and ‘Modelling a self’ constructs measures (Figure 3) can be exemplified with item 4F: [The mentors have] ‘Talked about the role of STEM in society’. In choosing what to elaborate on when talking about the role of STEM in society, significant persons provide the focal individual with insight not only into STEM but also into the mentors’ interests and the matters close to their hearts. This indicates that interests and societal engagement are important elements in what constitutes a ‘role’. Conclusively, in addition to the defining/modelling and self/object dualities, an introspective/extrospective duality may be used as a frame to investigate significant person influence.

Figure 3. Item loadings to the first (PC1) and second (PC2) principal component given by PCA of person-by-item residuals
Conclusions

Based on theoretical considerations as well as a previously published instrument (Nauta & Kokaly, 2001), the SPIAS instrument is now available for use. Its psychometric properties are presented in this article, and the instrument can be used to provide insight into significant persons and the different ways in which they influence STEM attitudes. Further validation and development is both welcome and recommended, making SPIAS even more valid and applicable. In particular, the context of application may vary, e.g. interventions in schools, local communities, and industry, and interventions aimed at parents. Moreover, the instrument can be used to investigate interpersonal influence, e.g. with respect to gender, ethnicity, socioeconomic status, etc. Using the instrument in other contexts than in a mentoring programme may require some other or additional items. The pilot version had 31 items, many of which hold high psychometric quality. These may be candidates to use as replacements if one or a few of the items in the final version of SPIAS are inappropriate for the context at hand. SPIAS was piloted in Norwegian, and translating it to other languages and using it in cultures different from the Norwegian culture may influence the precision of the instrument. Nonetheless, SPIAS is a valid starting point for anyone interested in developing equivalent instruments in other languages, contexts, and cultures.

Significant persons hold important roles in most aspects of life, and further investigation of significant person influence is highly relevant for science educators. SPIAS was developed with respect to interventions aimed at influencing young people’s attitudes towards STEM. When studying the effects on attitudes of such interventions, the use of validated and sound attitude instruments is recommended. Many promising attitude instruments exist, e.g. the instrument developed by Kind et al. (2007). The inclusion of SPIAS in attitude studies’ post-tests may provide insight into how the significant persons involved in the intervention contribute to attitude change. The potential benefits of using significant persons to inspire and motivate girls and boys to choose STEM in upper secondary and tertiary education are frequently pointed out (e.g. Aschbacher et al., 2010; Buck, Clark, Leslie-Pelecky, Lu, & Cerda-Lizarraga, 2008; Cleaves, 2005). SPIAS offers a unique way to develop and improve interventions involving significant persons, and thus it takes part in the effort of letting young people see the importance and joy of being engaged in STEM.

References


Appendix 1. Nauta and Kokaly’s (2001) IOACDS

Responses to these items were given by ranking the statements from ‘1 (strongly disagree)’ to ‘5 (strongly agree)’.

Support/guidance subscale items:

- There is someone who supports me in the academic and career choices I make
- There is no one who shows me how to get where I am going with my education or career (reversed)
- There is someone who helps me weigh the pros and cons of academic and career choices I make
- There is someone who tells or shows me general strategies for a successful life
- There is someone who stands by me when I make important academic and career decisions
- There is no one who supports me when I make academic and career decisions (reversed)
- There is someone who helps me consider my academic and career options
- There is someone I can count on to be there if I need support in my academic and career choices

Inspiration/modelling subscale items:

- In the academic or career path I am pursuing, there is someone I admire
- I know of someone who has a career I would like to pursue
- In the academic or career path I am pursuing, there is no one who inspires me (reversed)
- There is someone I am trying to be like in my academic or career pursuits
- There is no one particularly inspirational to me in the academic or career path I am pursuing (reversed)
- I have a mentor in my academic and career pursuits
- There is someone whose lifestyle I admire and strive for myself
Appendix 2. SPIAS Pilot Questionnaire

Dear participant in ENT3R,

This questionnaire will take about 4 minutes to complete, and concerns the mentors and your relationship to them. This investigation is a part of research project about what inspires young people to choose science, technology, engineering, and mathematics.

- If you have had several mentors, you can think of the mentors you have had the longest.
- Participation is voluntary. The questionnaire is anonymous. Responses from all groups in ENT3R will be mixed, so that no mentor will ever get to see the results from his/her group.
- It is very important to us that you answer as truthfully as you can.

1. Are you a girl or a boy?  
   - [ ] Girl  
   - [ ] Boy

2. To which extent have you experienced that your mentors have done the following?
   - [ ] Small extent  
   - [ ] Large extent
   a. Talked about careers I can get with an education in STEM.
   b. Shown new sides of mathematics.
   c. Talked about why I should continue choosing STEM.
   d. Shown examples of how maths can be applied.
   e. Talked about different studies I can take in STEM.
   f. Shown what people with a STEM education do at work.
   g. Shown maths in different ways than in school.

3. To which extent do the following statements hold?
   - [ ] Small extent  
   - [ ] Large extent
   a. The mentors have contributed so that I have explored whether I have disposition for maths.
   b. Through my mentors I have learned more about maths.
   c. The mentors have been important for how much self-confidence I have in maths.
   d. The mentors have shown me whether it fits me to be a STEM student.
   e. I have an impression of what the mentors think about their studies.
   f. The mentors have been important for how well I understand maths.
   g. I have an impression of what the mentors are like as persons.
   h. The mentors have been important for how much I enjoy doing maths.
   i. The mentors have shown me examples of what kind of qualities STEM students can have.
   j. The mentors have been important for my belief that I will reach the goals I set for myself in maths.
4. To which extent have you experienced that your mentors have done the following?

<table>
<thead>
<tr>
<th>Small extent</th>
<th>Large extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

- a. Talked about who can master STEM.
- b. Shown maths from a new perspective.
- c. Talked about what I can use STEM for.
- d. Talked about STEM studies at university.
- e. Shown interesting maths examples.
- f. Talked about the role of STEM in society.
- g. Shown new ways to solve maths exercises.

5. To which extent do the following statements hold?

<table>
<thead>
<tr>
<th>Small extent</th>
<th>Large extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

- a. I have an impression about how the mentors experience their studies.
- b. The mentors have been important for how motivated I am to do STEM.
- c. The mentors have been important for how much I am able to do in maths.
- d. I feel that I know my mentors.
- e. The mentors have contributed so that I have discovered my abilities in maths.
- f. The mentors have shown me how STEM students can be.
- g. The mentors have contributed so that I have learned something about myself.

6. Relationship to mathematics and future choice of education

<table>
<thead>
<tr>
<th>Like it less</th>
<th>Unchanged</th>
<th>Like it more</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- a. How has your relationship to maths changed because of ENT3R?
- b. The probability of you choosing a university or university college education within STEM; is it smaller, unchanged, or greater because of ENT3R?

7. Is there anything you want to comment on?

Thank you for your contribution!
APPENDICES
Appendix 1: The *Lily* questionnaire

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>

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>

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>To small extent</th>
<th>To great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Newspaper articles</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>b. Popular science book and magazines</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>c. Other books and magazines</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>d. PR posters and advertisements</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>e. Internet</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>f. Computer games</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>g. Museum/science center</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>h. Popular science television channels/programs (Discovery channel, Newton, Myth busters, Schrödinger's cat and so on)</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>i. Films and TV series (CSI, Numbers, Grey's Anatomy and so on)</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>j. The national science week</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>k. <a href="http://www.forskning.no">www.forskning.no</a></td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>l. Nysgerrigper (magazine, website, competition)</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>m. PR film about firemen and princesses</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>n. Statkraft's movie with April fools' joke about star power</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>o. Aker's nutcracker films</td>
<td>□ □ □ □</td>
</tr>
</tbody>
</table>

Other/comment: ________________________________

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

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

Comment: _____________________________________

243
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>

244
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>Helping other people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>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>Working with something that is important for society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with something that fits my beliefs and values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with something I find meaningful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making my own decisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working independently of other people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making lots of money</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting TV or media exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting leadership responsibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with something practical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with something easy and simple</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing new knowledge and insight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doing research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working creatively</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Designing and creating something new</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creating something that means something to other people</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Having lots of leisure time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building or repairing things</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing technology for renewable energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing computer or communication technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>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 href="http://www.jobbfeber.no">www.jobbfeber.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.velgrikig.no">www.velgrikig.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.utdanning.no">www.utdanning.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.utdanningsmagasinet.no">www.utdanningsmagasinet.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.studiestart.no.no">www.studiestart.no.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.finnstudie.no">www.finnstudie.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.norskindustri.no/ung">www.norskindustri.no/ung</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.gronnboks.no">www.gronnboks.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.teknovest.no">www.teknovest.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.utog.no">www.utog.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.7etg.no">www.7etg.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.energiutdanning.no">www.energiutdanning.no</a></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td><a href="http://www.shift.no">www.shift.no</a></td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

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

Background information

a. Mother’s highest level of completed education
   (□ don’t know/does not apply) ................................................................. □ □ □

b. Father’s highest level of completed education
   (□ don’t know/does not apply) ................................................................. □ □ □

c. Step-parents’ highest level of completed education
   (□ don’t know/does not apply) ................................................................. □ □ □

Has at least one of your parents/step-parents studied mathematics, science or technology (e.g. engineer, technician, researcher/scientist or teacher in mathematics, biology, chemistry, physics, etc.)?
   □ Yes □ No □ Don’t know

Did you speak a non-Western language at home when you grew up?
   □ Yes □ No 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.
Appendix 2: Focus group interview guide, the ENT3R project

INTRODUCTORY QUESTIONS
- Why did you sign up for the ENT3R project?
- What expectations did you have to the project when it started?

MAIN QUESTIONS
- Could you tell us how you experience participating in ENT3R?
- What has ENT3R meant to you with regard to a future choice of maths and science?
- How would you describe your mentors?

SUPPORT QUESTIONS
Expectation of success
- What has ENT3R meant to you with regard to your belief about what you can master in maths?
- How has ENT3R influenced how good you are in maths?
- How has your maths confidence changed because of ENT3R?

Attainment value
- After completing an exercise at ENT3R, have you ever felt that ‘it was good to manage this exercise’? If so, could you tell about that experience?
- How has ENT3R influenced your impression of people choosing maths and science? (If possible: How does this fit to the person you are?)
- Can you imagine yourself among other STEM students? (If possible: Has your participation in ENT3R influenced your thoughts about this?)
- Do you think of yourself as a typical maths person? (If possible: Has your participation in ENT3R influenced your thoughts about this?)

Interest-enjoyment value
- What has ENT3R meant to you with regard to how much you enjoy maths? (If possible: In which ways have maths become more interesting?)
- Could you tell about something fun you did in ENT3R? (If possible: What characterises the fun situations?)

Utility value
- What has ENT3R showed you about future opportunities provided by the maths you learn now?
- What have you learned from the career nights?
- How useful is maths with regard to educations, careers, or other goals you have? (If possible: Has your participation in ENT3R influenced your thoughts about this?)

Relative cost
- What do your friends think about people who choose maths? (If possible: Has your participation in ENT3R influenced your or their thoughts about this?)
- What has ENT3R meant to you with regard to how you deal with not managing an exercise?
- How does continuing with maths fit to other interests and plans you have? (If possible: Has your participation in ENT3R influenced your thoughts about this?)
- Does continuing with maths collide with other subjects or other activities? (If possible: Has your participation in ENT3R influenced your thoughts about this?)

FINAL QUESTIONS
- Could you share your best memories from ENT3R?
- Why did you stay in the project?
- Is it anything about the project we have not yet discussed that you want to talk about?
Appendix 3: Information letter, 16 years old or older ENT3R participants

Dear participant in ENT3R: The research project Lily invites you to take part in a focus group

Lily is a Norwegian research project concerning young people’s educational choices. The aim is to investigate how the natural sciences, mathematics, and technology might become more attractive to students. Therefore, we wish to look at different efforts, like ENT3R, to investigate in which ways these projects work.

You are invited to a focus group. This means that you participate in a group of 5–8 persons and discuss different topics concerning ENT3R. We want to learn about your experiences from the project and to what degree this has meant something for how you view mathematics. The discussion will last for 45–60 minutes, and takes place immediately after the maths training. Sound recordings will be made. We will serve pizza as a reward for your participation.

This project is approved by the Data Protection Official for Research, Norwegian Social Science Data Services, and collection, storing, and reporting of data will be according to the guidelines of the law of personal information storage. The collected information will be treated confidentially, and only by persons employed at this project.

The results from this investigation will be presented in a way that it is impossible to trace the information back to the persons that participate in the research. The sound recordings will be deleted and all information will be made anonymous by the end of the project in January 2081.

Participation is voluntarily, and you can withdraw at any time without having to provide an explanation. We do hope, however, that as many as possible want to participate, to provide us with a thorough image of how participants experience ENT3R.

If you have any questions about this research, you can give these to Jørgen Sjaastad, 22856478, jorgen.sjaastad@matnat.uio.no, or to Fredrik Jensen, 22857264, fredrik.jensen@naturfagsenteret.no. See also http://www.naturfagsenteret.no/vilje-con-valg for more information.

Best regards

Ellen K. Henriksen   Fredrik Jensen   Jørgen Sjaastad
Project leader    Researcher    PhD scholarship student
University of Oslo   Norwegian Centre for Science Education   University of Oslo

Notification of approval:

I have received information about the research on the ENT3R project, and I give my approval to take part in the research.

Your name: ________________________

Your signature: _________________________ Phone number: ___________________
Appendix 4: Information letter to parents/caretakers of 16 years old or older ENT3R participants

Dear parents/caretakers: Focus group interviews about the ENT3R project

Information about the Lily project
With this letter, we wish to inform you about the Lily research project and the focus groups we plan to conduct with participants in ENT3R. Your son/daughter participates in ENT3R, a mathematics training project lead by NHO and TEKNA, among others.

The project’s background and aim
Lily is a Norwegian research project about young people’s participation in STEM. The aim is to shed light to relevant factors when young people choose subject specialisation, education, and career. The project focuses at students in upper secondary school and tertiary education, and the overall aim is to increase recruitment to STEM educations.

The content of this investigation
The students are invited to a focus group. This means that they participate in a group of 5–8 persons and discuss different topics concerning ENT3R. We want to learn about their experiences from the project and to what degree this has meant something for how they view mathematics. The discussion will last for 45–60 minutes, and takes place immediately after the maths training. Sound recordings will be made. We will serve pizza as a reward for participation.

Anonymity and storage of data
This project is approved by the Data Protection Official for Research, Norwegian Social Science Data Services, and collection, storing, and reporting of data will be according to the guidelines of the law of personal information storage. The collected information will be treated confidentially, and only by persons employed at this project.

The students’ rights
Participation is voluntarily, and they can withdraw at any time without having to provide an explanation. We do hope, however, that as many as possible want to participate. If you want to keep your daughter/son from participating, or have any other questions, please contact Jørgen Sjaastad, 22856478, jorgen.sjaastad@matnat.uio.no, or Fredrik Jensen, 22857264, fredrik.jensen@naturfagsenteret.no. And feel free to visit our webpage http://www.naturfagsenteret.no/vilje-con-valg, for more information about our project.

Best regards

Ellen K. Henriksen
Project leader
University of Oslo

Fredrik Jensen
Researcher
Norwegian Centre for Science Education

Jørgen Sjaastad
PhD scholarship student
University of Oslo
Appendix 5: Focus group interview guide, SPIAS development

Introduction: Why did you join the ENT3R project?
[Which expectations did you have when you joined the project?]

Main question
What have your mentors meant for your considerations about choosing maths and science in the future?

Modelling a self: Can you please tell me about your mentors?

i) The person: How would you describe your mentor as a person? [What are the most important qualities a mentor should have?] [How do the mentors influence the mood at the maths trainings?]

ii) The student: What do you know about the mentors’ lives as students? [How do you think you would have enjoyed the education of your mentors, with the same subjects and the same student friends?]

Modelling STEM: Can you please tell me about the maths training the mentors provide you?

i) Fun: What have your mentors meant for how much you enjoy to do maths? [What do the mentors do to make maths more interesting?]

ii) Pedagogy: What have your mentors meant for how skilled you are in maths? [What have your mentors taught you about solving strategies and new perspectives on maths?]

Defining self: Can you please describe your relationship to your mentors?

[How well do the mentors know you?] [What kind of topics do you talk with the mentors about?]

What have your mentors meant for your belief in what you can achieve in maths?
[What do the mentors do to motivate you?]

Defining STEM: What have your mentors told you about the utility of maths and science?

i) Utility: What have your mentors told about the utility of maths with respect to education, career, or other goals?

ii) Necessary skills: What have your mentors told about the skills one should have to study maths and science?

Final questions
You who believe you will choose science in the future: What might the mentors do to make you more certain about your choice?

You who believe you will not choose science in the future: What would the mentors have to convince you about to make you consider it?

What is the best thing about your mentors?

Is it something about the ENT3R mentors that we have not yet discussed, that you want to share?
Appendix 6: Pilot version of SPIAS

Dear participant in ENT3R

This questionnaire will take about 4 minutes to complete, and concerns the mentors and your relationship to them. This investigation is a part of research project about what inspires young people to choose science, technology, engineering, and mathematics.

- If you have had several mentors, you can think of the mentors you have had the longest.
- Participation is voluntary. The questionnaire is anonymous. Responses from all groups in ENT3R will be mixed, so that no mentor will ever get to see the results from his/her group.
- It is very important to us that you answer as truthfully as you can!

1. Are you a girl or a boy?  
   - Girl  
   - Boy

2. To which extent have you experienced that your mentors have done the following?

   ![Small extent](image1) ![Large extent](image2)

   a. Talked about careers I can get with an education in STEM.
   b. Shown new sides of mathematics.
   c. Talked about why I should continue choosing STEM.
   d. Shown examples of how maths can be applied.
   e. Talked about different studies I can take in STEM.
   f. Shown what people with a STEM education do at work.
   g. Shown maths in different ways than in school.

3. To which extent do the following statements hold?

   ![Small extent](image3) ![Large extent](image4)

   a. The mentors have contributed so that I have explored whether I have disposition for maths.
   b. Through my mentors I have learned more about maths.
   c. The mentors have been important for how much self-confidence I have in maths.
   d. The mentors have shown me whether it fits me to be a STEM student.
   e. The mentors have shown me whether it fits me to be a STEM student.
   f. The mentors have been important for how well I understand maths.
   g. I have an impression of what the mentors are like as persons.
   h. The mentors have been important for how much I enjoy doing maths.
   i. The mentors have shown me examples of what kind of qualities STEM students can have.
   j. The mentors have been important for my belief that I will reach the goals I set for myself in maths.
4. To which extent have you experienced that your mentors have done the following?  

<table>
<thead>
<tr>
<th>Statement</th>
<th>Small extent</th>
<th>Large extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Talked about who can master STEM.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. Shown maths from a new perspective.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>c. Talked about what I can use STEM for.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>d. Talked about STEM studies at university.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>e. Shown interesting maths examples.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>f. Talked about the role of STEM in society.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>g. Shown new ways to solve maths exercises.</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

5. To which extent do the following statements hold?  

<table>
<thead>
<tr>
<th>Statement</th>
<th>Small extent</th>
<th>Large extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I have an impression about how the mentors experience their studies.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. The mentors have been important for how motivated I am to do STEM.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>c. The mentors have been important for how much I am able to do in maths.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>d. I feel that I know my mentors.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>e. The mentors have contributed so that I have discovered my abilities in maths.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>f. The mentors have shown me how STEM students can be.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>g. The mentors have contributed so that I have learned something about myself.</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

6. Relationship to mathematics and future choice of education  

<table>
<thead>
<tr>
<th>Statement</th>
<th>Like it less</th>
<th>Unchanged</th>
<th>Like it more</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. How has your relationship to maths changed because of ENT3R?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statement</th>
<th>Smaller</th>
<th>Unchanged</th>
<th>Greater</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. The probability of you choosing a university or university college education within STEM; is it smaller, unchanged, or greater because of ENT3R?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

7. Is there anything you want to comment on?  

Thank you for your contribution!

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