SOURCES OF INSPIRATION

The role of significant persons in young people's choice of science in higher education

Jørgen Sjaastad, jorgen.sjaastad@matnat.uio.no, University of Oslo

ABSTRACT

The objectives of this article are 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. 5007 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.
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 understanding of how persons may contribute to improve recruitment to STEM related educations. Questionnaire data from 5007 Norwegian STEM students in the research project Lily (Schreiner, Henriksen, Sjaastad, 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 wanting to be engaged 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 (2008) 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 aiming to improve 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-Lizarraga (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 where this term 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' (Aron, et al.).
Interpersonal influence on the self is a main idea also in 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 stands in 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 aims to understand the priorities, experiences, and motivational
factors underlying young people's educational choice. Pen-and-paper questionnaires were
used to collect the data in the 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, physics), and
mathematics (Schreiner, Henriksen, Sjaastad, Jensen, & Løken, 2010).

All 26 universities and university colleges in Norway offering STEM educations are public.
25 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 given the questionnaire chose to complete it. Nevertheless, the
respondents of project Lily constitute about 70 % of the total number of STEM students
beginning their education 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 work load of the coordinators accounts for the majority of students in our target group that
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 beginning 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 with the items used in this article is given in the appendix. We will analyse and discuss five closed questions (Question 14 a – e), two open-ended questions (Question 16 and 20), and one combined question (Question 19 k).

**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 an *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 box 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 (SPSS, 2007). 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 19 k, with 11.4% missing values. The high percentage of missing values on this question might be due to the questionnaire design, 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 a 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 19 k will be analysed together. They will not be analysed separately because the questions overlap to some degree. Suggesting that a statement concerning significant persons means something different written as a response to e.g. Question 16 and 20 (see appendix) will not contribute to our discussion in any important way. NVIVO 8 (NVIVO, 2008) was used as a tool to organize 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 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. E.g. 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%, 2066 respondents, attribute one or several significant persons with a major degree of inspiration.

Figure 1. 'To what extent have you been inspired or motivated by the following in your choice of study programme?' Percentages in the four response categories from 'to a small extent' (light grey) to 'to a great extent' (dark grey). The significant persons are sorted by mean scores (in parentheses) calculated from a scale ranging from 1 (to a small extent) to 4 (to a great extent).

Among the 5007 respondents, a total of 1664 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 (Row 1 – 5) are people with whom the respondent stands in 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.

Table 1: Significant persons mentioned in open-ended questions

<table>
<thead>
<tr>
<th>Description</th>
<th>Descriptions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Teachers</td>
<td>389</td>
<td>23 %</td>
</tr>
<tr>
<td>2. Parents, fathers, mothers</td>
<td>304</td>
<td>18 %</td>
</tr>
<tr>
<td>3. Siblings, family, and relatives</td>
<td>286</td>
<td>17 %</td>
</tr>
<tr>
<td>4. Friends and sweethearts</td>
<td>223</td>
<td>13 %</td>
</tr>
<tr>
<td>5. Acquaintances</td>
<td>198</td>
<td>12 %</td>
</tr>
<tr>
<td>6. Other people*</td>
<td>179</td>
<td>11 %</td>
</tr>
<tr>
<td>7. Celebrities</td>
<td>85</td>
<td>5 %</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1664</td>
<td>100 %</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'.

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 on who they are as individuals (Schreiner, et al., 2010). They have a clear impression of the educational choice as something depending primarily on their personality. This is probably part of why persons were rated relatively low (Figure 1). However, the many 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 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 one or more of the three 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 respondents, there are almost as many descriptions of significant persons given by women as by men.
Table 2: Significant persons mentioned in open-ended questions with respect to gender

<table>
<thead>
<tr>
<th></th>
<th>1683 women</th>
<th></th>
<th>3324 men</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Descriptions</td>
<td>Percentage</td>
<td>Descriptions</td>
<td>Percentage</td>
</tr>
<tr>
<td>1. Teachers</td>
<td>223</td>
<td>13 %</td>
<td>166</td>
<td>5 %</td>
</tr>
<tr>
<td>2. Parents, fathers,</td>
<td>149</td>
<td>9 %</td>
<td>155</td>
<td>5 %</td>
</tr>
<tr>
<td>mothers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Siblings, family,</td>
<td>124</td>
<td>7 %</td>
<td>162</td>
<td>5 %</td>
</tr>
<tr>
<td>and relatives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Friends and</td>
<td>84</td>
<td>5 %</td>
<td>139</td>
<td>4 %</td>
</tr>
<tr>
<td>sweethearts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Acquaintances</td>
<td>71</td>
<td>4 %</td>
<td>127</td>
<td>4 %</td>
</tr>
<tr>
<td>6. Other people*</td>
<td>97</td>
<td>6 %</td>
<td>82</td>
<td>2 %</td>
</tr>
<tr>
<td>7. Celebrities</td>
<td>28</td>
<td>2 %</td>
<td>57</td>
<td>2 %</td>
</tr>
<tr>
<td>TOTAL</td>
<td>776</td>
<td>46 %**</td>
<td>888</td>
<td>27 %**</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’.

**These numbers are slightly too high. A few respondents wrote about more than one significant person.

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 existing research: Gabriel and Gardner (1999) found that women describing themselves emphasized 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 part of why so many teachers, given the opportunity to influence specific self-views concerning STEM abilities, are mentioned by women compared to men.

Looking more closely at the descriptions of parents, we find that fathers are mentioned more than six times as frequently as mothers (Table 3). The great gender difference in the STEM labour marked in Norway is an important reason why this is, indicated by the many descriptions of fathers who are or have been engaged in a similar subject area. These fathers have been models, displaying a self engaged in STEM. To the extent that mothers are described as having inspired or motivated respondents, they have relatively more often inspired through personal support and conversations, thereby defining the students' selves. 21 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.

Table 3: Fathers, mother, and parents mentioned in open-ended questions

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fathers</td>
<td>60 %</td>
</tr>
<tr>
<td>2. Parents</td>
<td>32 %</td>
</tr>
<tr>
<td>3. Mothers</td>
<td>9 %</td>
</tr>
<tr>
<td>TOTAL</td>
<td>101 %*</td>
</tr>
</tbody>
</table>

*Does not sum up to 100% due to round-off error.

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 to 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 to 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. ‘To what extent have you been inspired or motivated by the following in your choice of study programme? Parents or step-parents’. Percentages in the four response categories from ‘to a small extent’ (light grey) to ‘to a great extent’ (dark grey). The student groups are sorted by mean scores (in parentheses) calculated from a scale ranging from 1 (to a small extent) to 4 (to a great extent).

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 like 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 does 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.

Figure 3. To what extent have you been inspired or motivated by the following in your choice of study programme? Teachers'. Percentages in the four response categories from 'to a small extent' (light grey) to 'to a great extent' (dark grey). The student groups are sorted by mean scores (in parentheses) calculated from a scale ranging from 1 (to a small extent) to 4 (to a great extent).

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.
Table 4: Responses coded in Woelfel and Haller's framework

<table>
<thead>
<tr>
<th></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>

**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 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 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 to 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 ten 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. All 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 that 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 models 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' (ibid., 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 to 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'.

**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. Firsthand 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 a 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 toward 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 (2010) 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 recognized 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' (ibid.). 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 to 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 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 stand in 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 stand in interpersonal relationships with young people. If they read about different aspects of STEM related educational choices, they can identify and promote the information 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 see 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 in interpersonal relationships with young people influence their choice of a STEM education.

**ACKNOWLEDGEMENTS**

The author would like to thank the project group, administrators, and participants of project Lily. In particular, Ellen Karoline Henriksen at the University of Oslo is acknowledged for her valuable comments and discussions with the author.
REFERENCES


Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students’ identities, participation and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching, 47*(5), 564-582.


Holmegaard, H. T. (2010). Upper secondary students' identity work and meaning making process when choosing higher education. University of Copenhagen, Department of Science Education.


Appendix: An excerpt from the questionnaire

18. How important were these factors for your choice of study?
   Not important  Very important
   a. The subjects offered  b. To study at this particular university (college)  c. Siblings, half siblings, step siblings, parents or step parents  d. Teachers  e. School counsellor  f. Other people I know  g. Parents or step parents  h. Friends and/or boyfriend/girlfriend  i. Teachers  j. Other persons who made an impression, or other ….

19. Which other persons made an impression, or other factors influenced your current choice of education?
   □ Other persons who made an impression, or other factors influenced your current choice of education

20. What extent do you agree with the following statements?
   To great extent  To a great extent  To some extent  To a lower extent  Not at all
   a. Good facilities, beautiful campus areas, library, reading rooms, sports facilities, buildings, common areas, cafés, library, reading rooms, sports facilities
   b. Small and intimate social environment
   c. Large and diverse social environment
   d. Near my home  In a smaller place  Not too near my home
   e. To what extent have you been inspired or motivated for your choice of study from the following?
      □ Publicly known persons in the media
      □ Visit(s) the Internet pages of the university (college)
      □ Cinema advertisements for the university (college)
      □ Education exposition
      □ School counsellor
      □ The location of the university (college) in a certain part of the country
      □ The subjects offered
      □ Other people I know  Siblings, half siblings, parents or step parents  Friends and/or boyfriend/girlfriend
      □ Teachers
      □ Other persons who made an impression, or other factors influenced your current choice of education

21. To what extent have you been inspired or motivated by the following in your choice of study?
   □ Publicly known persons in the media
   □ Visit(s) the Internet pages of the university (college)
   □ Cinema advertisements for the university (college)
   □ Education exposition
   □ School counsellor
   □ The location of the university (college) in a certain part of the country
   □ The subjects offered
   □ Other people I know  Siblings, half siblings, parents or step parents  Friends and/or boyfriend/girlfriend
   □ Teachers
   □ Other persons who made an impression, or other factors influenced your current choice of education