D2.1 Conceptual Framework

Project title: Promoting Youth Scientific Career Awareness and Its Attractiveness through Multi-stakeholder Cooperation

Project Acronym: MultiCO

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2.1.1 Introduction

The aim of the MultiCO project is to raise students' interest in science and awareness of careers in science, and their aspirations regarding choosing science for study. The project builds on previous research in order to understand and address the issues needed for bringing about changes in perceptions and influencing choice.

The project sets out to address the problem of declining interest in science and the challenges faced by young people in choosing science, technology, engineering and innovation related careers by promoting greater familiarisation with the diversity of careers in these fields. The project strives to promote an awareness and motivation for young people to make informed choices by developing skills such as creativity, reasoning and co-operation (collaboration) using, where appropriate, scientific inquiry-based learning approaches. The project focuses on the learning of science and the orientation of students towards an awareness of, and choosing, scientific careers. The project focuses on innovative scenarios as part of science education. Societal issues considered in career-based scenarios allow links to be made between entrepreneurial and multidisciplinary research careers and the associated skills required. In the learning process, self-determination by working with open-access educational resources is encouraged, science and social media being used, and links between creativity and scientific endeavours made, as well as ethics discussed. The topics of the innovative, career-based scenarios are ones relevant to Europe; food, health, water, waste, energy, digital challenges, biomass and transport. Co-operation at the science and career levels is with research institutes, entrepreneurs, industry, and civil society organisations with a view to a multi-stakeholder cooperation ensuring modern, innovative and motivationally attractive scenarios.

To achieve its aims the project builds on literature research outcomes, initially and as the project progresses, and proposes to study the impact of real-life related, career focused stories (referred to as scenarios) as the introduction to the learning of science subjects by secondary school students (ages 13 to 15). Through such an innovative development focusing on initiating motivational and meaningful context and inquiry-based science studies, the project researches the impact on learning and attitudinal gains, as well as students' own ideas to enhance the relevance of science studies. The literature on motivation, interest and attitudes is wide-ranging beyond the field of science education. In the literature research the project will make an initial review of key concepts that will inform the methodology, and continue to review research that comes to light as the project progresses. The reviews have been undertaken through a combination of systematic searching under key words, and key journals and sources known to experts in the partnership.

The target of the project is to increase students' future preferences for choosing science studies and their desire to reflect on and pursue science-related careers. There has been a general educational trend towards context-based approaches and viewing science education as being education through the context of science. Context-based approaches and strategies that actively engage students in the learning process have been shown to result in improvement in students' attitudes towards science, although the need for students to input their ideas and their indigenous knowledge should be taken into account. A review of the key science activities that promote interest and engagement in science

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and science careers will be important to inform the development of career –based scenarios and subsequent inquiry and context based approaches that can be deployed in the intervention methodology.

Research has shown that middle grade students are not aware of career options, are not conversant with competences needed and few indicate knowing professionals actively working in the science, technology, engineering and mathematics fields. Yet in recruiting graduates, employers have indicated that a range of skills is important and that the most important skills are team working, sector-specific and communication skills. The intended project outcome is to raise youth awareness of the role of science and technology in society, an awareness of science and technology careers and orientation of students towards gaining positive views towards undertaking science careers. To this end the literature on counseling, including the nature and process of career advice available and its impact, will inform the project of how interventions around career-based scenarios can have impact on choice.

There is a substantial amount of research that has focused on the reasons for subject and career choice, which are elated to the motivation, interest and attitudes, the pedagogical approaches and the available advice and awareness regarding careers. By undertaking a literature review the project aims to define a clear and detailed conceptual framework comprising of the issues related to motivate students towards science education and the factors to be addressed in all subsequent stages of the research. This is achieved initially by extensive meta-analysis of the literature; the analysis establishes criteria for comprehensively and consistently coverage of all aspects determined as relevant to the concepts mentioned in the project, (mainly including: interest, motivation, relevance, attractiveness, scenarios, careers, study choices in science education).

Issues of particular interest to the development of the conceptual framework are recognised as:
- Definitions and aspects of interest, motivation, relevance, attitudes, particularly as these relate to possible interventions or teaching approaches in science
- The diversity and dominance of societally-oriented teaching approaches, context-based teaching
- Issues indicated by stakeholders, science education literature and career presentation documents.
- Issues relating to study and careers choices.

The conceptual framework therefore encompasses theoretical perspectives and knowledge from four inter-related strands of research:

Motivation, interest, attitudes
Activities for promoting STEM careers
Counselling for STEM careers
Subject and career choice

There is a distinct overlap in this conceptual framework between these four areas; each has been explored in the literature to identify issues around students' awareness and choices regarding science related careers. All partners have contributed to all areas, but

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individual partners have synthesised each aspect, as indicated in the sections of the framework below.

Prior to a more detailed analysis of literature in these four areas, our review of one article in particular requires a special mention as it has informed the project across all aspects. The major review article by Potvin and Hasni (2014) presents a systematic description of 228 peer-reviewed research articles in a 12-year period (2000 – 2012) that were indexed in the ERIC database under interest/motivation/attitude (I/M/A) towards science and technology (S&T) at K-12 levels. The paper departs from the premise that students' interest in S&T has declined and S&T professions are becoming less attractive to students, and sets out to describe the variation in students' interest, motivation and attitude toward S&T from kindergarten to the end of the secondary school.

The six sub-research questions used for exploring the articles focus on geographic origin, the general character of the articles' categories, the main constructs and general definitions that authors give to address the I/M/A issue, the data sources used to assess I/M/A, the links that exist between I/M/A and other variables, and the best ways to improve I/M/A toward S&T in and out of class.

Regarding the main constructs in the research articles, interest was considered as the main driver and the key factor in career decisions. The data collected were both quantitative and qualitative, and questionnaires held the forefront of the data collection methods in the studies. Gender differences make up the largest subcategory of the variables linked to I/M/A. According to the articles reviewed, the best ways to improve I/M/A toward S&T in and out of class include:

- summer camps/competitions/science fairs/field trips
- inquiry or problem-based learning/hands-on learning
- ICT intervention
- collaborative work (models such as 'jigsaw' or 'collaborative instruction')
- good contextualization interventions (by linking S&T and reality)
- science museums; contact with role-models
- giving enough opportunities to both genders
- teacher training; multi-angle programmes
- improving the evaluation process in a S&T context and other interventions (such as 'cycle of rocks' topic, 'advanced organizers' e.g. charts etc.)

As Potvin and Hasni (2014) concluded, well targeted efforts based on well-documented sources usually increase I/M/A. Furthermore, they suggest that studying I/M/A for particular themes, disciplinary elements or contexts with all students and not merely girls, would be more insightful as deeper differences appear and the focus should be on 'how' S&T is taught. The message for MultiCO from this paper is that we should explore the ways in which science activities inform the development of our intervention scenarios and subsequent pedagogy. This aspect is dealt with in more detail in section 2.1.3 (Activities for promoting STEM careers).

Another observation is that I/M/A in S&T declines with school years. Significant differences between the elementary and secondary school courses might explain this decline. In addition, PISA analyses revealed negative correlations between interest and

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performance in tasks related to S&T. A possible gap between (a) what school concentrates on (or offers), (b) child preferences and (c) what is relevant to real-life contexts, could be (at least partly) held responsible for students' declining interest and motivation toward S&T. Potvin and Hasni (2014) have also observed that self-efficacy is linked to interest. Students who choose to pursue a career in S&T are those who have good self-esteem or consider themselves as good achievers and not those who express I/M/A in S&T in a high level. Hence, it is important to develop students' feelings of self-efficacy in S&T courses.

With regards to future research, the authors suggest using already developed instruments (e.g. SMQ2, TOSRA etc.) thus allowing comparisons. As a final observation, Potvin and Hasni (2014) argue that more longitudinal efforts should be made since interest should be considered as a long-term affair. MultiCO aims to do just that by implementing interventions that aim to interest and motivate students towards science-related careers, and adopt a methodology for capturing the impact of these interventions over a period of 2-3 years through carefully developed instruments. The methodology of MultiCO will set out to achieve this aim through distinguishing between successful and less successful approaches/interventions and to characterize these more closely (for example by establishing a list of characteristics or 'design principles'.

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2.1.2 Motivation, interest and attitudes (Task 2.2, lead partner UBO)

Introduction and overview

These three concepts are interlinked but have distinctive interpretations that underpin MultiCO research. Motivation is commonly understood as the state of wanting to perform a specific activity in a given situation (Schiefele, 2009), and has many component features (see below). Interest is a motivational concept that has content specificity; an interest is always directed towards an object, activity, field of knowledge, or goal. A distinction can be made between individual interest, where interest is interpreted as a relatively stable tendency to occupy oneself with an object of interest (Krapp & Prenzel, 2011), and situational interest – a state or an ongoing process during an actual interest-based activity (being interested). Krapp and Prenzel suggest that the difference between interest and attitudes arises with respect to the evaluation criteria that are the focus: "general, non personal evaluation viewpoints are decisive for an attitude to a particular object, whereas the subjective value attached to the knowledge about this object is important for interest" (p. 31). Thus, one can have a negative attitude towards something yet be interested to know more about it. The focus on interest in science and school science has contributed to our understanding of how attitudes may be shaped by both personal and environmental characteristics.

According to the "person-object theory of interest" (e.g. Krapp 2002), interest emerges from the interaction between a person and an object (a concrete thing, a topic, a subject-matter, or even an abstract idea). An interest represents a specific relationship between the person and the object. This relation is characterized by affective and cognitive components. Different phases of interest (from an emerging situational interest to a stable individual interest) can be characterized by varying amounts of affect, knowledge, and value (Renninger & Hidi, 2011). As a consequence, the instruments that will be developed for the project, will take into account these three facets of the interest construct: emotional (enjoy), cognitive/epistemic (knowing/wanting to know more), and value-related (considered to be important) aspects.

Essential to understanding the behaviours we are concerned with in MultiCO, that is engagement and subject choice with respect to science, is the need to ascertain the motivation, intrinsic or extrinsic, that underpins these behaviours. As pointed out in the review by Potvin & Hasni (2014), several studies point to declining motivation, interest or attitudes with age or school year That there exists a downward trend in students' motivation, interest and attitudes to science, has become widely accepted (Barmby *et al.*, 2008). This trend has implications for the ways in which students' make choices (e.g. Taskinen *et al*., 2013). The reasons for the decline in students' motivation for science with increased age are not fully understood, and could change over time, but studies have pointed to a lack of practical work, a less autonomous school atmosphere, anxiety in relation to grades and careers, and perceptions of school science as difficult, decontextualized and irrelevant to students' everyday lives (Lyons, 2006).

School science and teachers are considered as important factors determining students' views (Christidou, 2011). Further insights on interest come from studies focusing on specific aspects of school science, such as the subject matter, the context in which topics are presented, and activity formats – for example using technology (e.g. Swarat *et al*.,

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2012), and practical work (Abrahams, 2009). Potni and Hasni (2014), conclude from their extensive literature review that 'hands-on' activities, which do not require much reflection, do not have positive effects on students' interest, motivation and attitudes, whereas inquiry-based or problem-based interventions do have a positive effect. Collaborative work also has a positive effect. Basl (2011) looked at the impact of parents/ family background and school on students' interest in future science-related careers. Interest in science and future careers are influenced by the degree to which school prepares students for future education and careers, and creates awareness of science-related career opportunities.

Though motivation, interest and attitudes are closely related, our review of the literature shows that some authors focus differently on these concepts, as the following reviews show. In the first section we review articles that focus more specifically on attitudes, second those relating to motivation and interest.

Key articles on Attitudes to science

Osborne, Simon and Collins (2003), set out the main issues arising from an extensive review of the literature up to 2003. The authors explore what is meant by attitudes towards science, provide an overview of how attitudes have been measured, and discuss findings about the influences of gender and environment (including teaching) on attitudes, and what is known about the relationship between attitudes and achievement.

Osborne et al. point out that there has been a lack of clarity of meaning with respect to attitudes. These authors draw on earlier work to make a distinction between attitudes towards science and scientific attitudes; the latter being "a complex mixture of the longing to know and understand, a questioning approach to all statements, a search for data and their meaning, a demand for verification, a respect for logic, a consideration of premises and a consideration of consequences…these are the features that might be said to characterize scientific thinking" (p. 1053). Attitudes towards science on the other hand, are the "feelings, beliefs and values held about an object that might be the enterprise of science, school science, the impact of science on society or scientists themselves" (p.1053).

Osborne et al. draw attention to the complexity of attitudes, and the many constructs that can comprise attitudes. They also focus on the relationship between attitude, intention and behavior, with reference to the theory of reasoned action developed by Ajzen and Fishbein in the 1970s, which is concerned with predicting behavior. As Osborne et al. report, this theory has been applied to a range of attitude and behavior studies in science education, some of which demonstrate how attitudes towards school science (as distinct from science in society) influence choice to study science.

Many instruments have been devised to measure attitudes towards school science and both quantitative and qualitative methods have been used in attitude studies. Osborne et al. review subject preference studies that include the use of surveys that require students to rank subjects, and also focus group studies that explore views in more depth. Most common, however, is the use of questionnaires that consist of Likert scale items where students are asked to agree/disagree with various statements such as "science is fun"; "I would enjoy being a scientist" (p. 1057). Most scales use a five point range –

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strongly agree/agree/not sure/disagree/strongly disagree, and include a set of items designed to cover a range of constructs and which have been piloted to test for reliability. A number of examples are included in Osborne et al.'s review. These authors caution that scales that include items covering a range of different attitude constructs cannot lead to a single attitude score, as this would be meaningless. Examples of qualitative studies in Osborne et al.'s review point to their value in providing insights into the origins of attitudes to school science.

Osborne et al. report on a range of studies that show a decline in attitudes towards science in early adolescence, in some cases even earlier. A more detailed analysis of studies does highlight a distinction between attitudes towards science and attitudes towards school science, as many 15 year olds have positive attitudes towards science, finding it interesting, useful and relevant, particularly in relation to technological advances, whereas school science is seen as rooted in past discoveries.

Research undertaken between 1970 and 1990 demonstrated that boys had more positive attitudes to school science than girls (Osborne et al.). Analysis of reasons indicated a range of possibilities from the early childhood experiences of boys playing with more scientific toys, to perceptions of difficulty of the subject – girls believing themselves to be better at other subjects. Studies undertaken after 1990 provide evidence that girls believe themselves able to follow careers in science, even though they are less likely than boys to do so.

Students' attitudes to school science can vary according to subject (Osborne et al.), some findings indicate that biology is perceived as more relevant as it addresses students' interests in their own bodies and health and disease, whereas the physical sciences are seen as less relevant.

Though background factors such as parental influence and socio-economic status can play a part in contributing to students' attitudes towards science and school science, the most significant determinant of attitude is classroom environment (Osborne et al.) and in particular quality of science teaching: "Good teaching was characterized by teachers being enthusiastic about their subject, setting it in everyday contexts, and running well-ordered and stimulating science lesson…. talking with the students about science, careers and individual problems" (p. 1068). One important aspect of good teaching that these authors report is specialist knowledge, for example, low attitudes to science subjects could be attributed to teachers teaching outside their specialist subject with less enthusiasm.

The nature of any relationship between attitude and achievement has been a key concern of many studies, but the evidence is inconclusive regarding this relationship (Osborne et al.). While some studies show a positive correlation, others show that students can achieve highly in a subject without having a positive attitude towards it. Attitudes, once formed, may be relatively stable for individuals, but the shaping of attitudes is complex and also context dependent, which makes the task of determining attitudes in a changing world dynamic and never-ending. As Osborne et al. point out "attitude cannot be separated from its context and the underlying body of influences that determine its real significance" (p. 1055). Findings of studies conducted over different time periods relating to age, gender and cultural background do vary as different contexts and

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influences operate. Ongoing research is needed to capture changing trends in the relationship of age, gender and culture to attitudes towards science.

Barmby, Kind and Jones (2008) provide an analysis of and references to attitude studies, with specific commentary on a range of similar issues arising from their own research. They recognize three components of attitudes as cognition, affect, and behavior – "a person has knowledge and beliefs about objects that give rise to feelings about them, and these two components together may lead a person to take certain actions" (p. 1078). This definition of attitude is similar to that of student engagement as used in many other studies of student affect in science.

Barmby et al. measure clearly defined attitude constructs in their study using a questionnaire, these include "learning science in school; practical work in science; science outside of school; importance of science; self-concept in science; future participation in science" (p. 1077). The reliability values and factor analyses confirmed that the three factors of learning science in school, science outside of school and future participation in science could be brought together to provide a combined "interest in science" measure.

Barmby et al. found a steep decline in attitudes towards learning science between students aged 11 and 13. Qualitative evidence showed that reasons for this decline in attitudes included lack of practical or lab work, weak explanations and the perception that school science is not relevant.

As Barmby et al. report, more recent studies have shown that "who students want to be" has more prominence than previously, and conclude that attitudes are influenced by the current social contexts in which they are conducted. They also report that differences between boys' and girls' attitudes towards science outside school increases markedly with age, the difference being quite small at age 11 and more marked at age 13-14 years. Decline in attitudes to learning science in school occurs with both boys and girls, but is still more pronounced with girls.

From their own research, Barmby et al. found that, using a stepwise regression analysis, the construct that correlated most highly with the Future participation in science measure was the Science outside of school construct, however this becomes less important as students go through school, Learning science in school becomes more important. They suggest then that enjoyment in classrooms becomes more important for future participation.

Christidou (2011) explores the relationship between attitudes and interest and reports that physics is the least attractive discipline for girls, who tend to be more attracted to studying animals and health or aesthetic topics.

Christidou focuses more specifically on students' images of science and scientists that reveal gender stereotypes regarding professions perceived as scientific. Girls more than boys see science as: "competitive, impersonal, abstract, rule-founded, certainty-bounded, deprived of imagination and as a product of individual effort made exclusively by male scientists" (p. 144). Though her review of studies also suggests that boys are more interested in science than girls, particularly in relation to some subjects (see

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above), she has found convergence in male and female interest in topics related to human biology, plants and animals, light and sound and astronomy. Moreover, girls are more influenced by the interpersonal dimension – the presence of other people who they admire.

Christidou also reports on the relationship between negative attitudes and the way science is taught. Teachers themselves need to have a positive stance towards science and scientists in order to inspire their students. The situation is not helped when school science is fragmented into isolated disciplines, and is limited in how it addresses values and social issues.

Christidou's review also looks at the popular images of science in in relation to students' interest and attitudes towards science. In focusing on the implications of how science is perceived by students, she reviews studies that have aimed to enhance students' involvement in science through providing different learning environments. For example, she points out that involvement in a variety of informal out-of-school science activities may be associated with a firmer commitment to science and science learning. Research is still needed that looks at the way science is presented to students, including the values connected to science.

In a study about practical work, Toplis (2012) investigates learners' views about the use of practical work in their Key Stage 4 (ages 13 -16) science classes in West London. The author refers to previous studies conducted in Australia, Sweden and England where practical work features highly in students' attitudes towards, and enjoyment of, school science (p. 534).

Toplis notes the backdrop of declining attitudes towards science education in developed countries with a correlation between how developed a country is, and the negative attitudes expressed by students, i.e. greater negative attitudes in more developed countries. His study included nine science classes in three differing London schools that involved observation of science classroom lessons and extensive interviews with groups of students selected by their science teacher (29 students in total). The classroom observations indicated that each lesson had between three and five different activities during 60-minute lessons that included writing, reading, discussion, listening, practical work, ICT activities and questions and answers (p. 538). The interviews brought up a range of factors about practical work. Learners regarded practical work to be more fun, found it personally relevant, allowed more involvement, were more motivating and gave opportunities for group work that raised their interest.

In analyzing their comments in light of the classroom observations, Toplis notes that motivation can often be misconstrued for situated interest that is not prolonged after a practical activity or a science lesson where a practical activity was conducted. However, students expressed their belief that practical work helped them to remember key ideas more so than reading from a slide, a book or listening to the teacher.

The author concludes that practical work is seen as important by learners as it is able to engage more learners, boost their autonomy in class and help them remember scientific concepts often because it is viewed, by the learners, as more preferable to other forms of activities in science lessons, often only compared to reading and writing despite the

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author observing many more activities than this in the learners' science lessons. He concurs with other authors of studies that there needs to be more thought put into the learning objectives of teachers when employing practical work in lessons and how it can link the domain of objects and observables with the domain of ideas (p. 546). Finally he identifies the absence of discussion of scientific inquiry in this study but proffers a reason for this as being how learners in the schools involved in the study may link inquiry to practical summative assessments.

The pedagogical implications of promoting positive attitudes to science, and measuring any changes that occur, are central to the MultiCO project. Providing a base-line which ascertains attitudes prior to intervention will be followed by teaching and learning scenarios that are based on those aspects that have been shown to have a positive impact on students' behaviour towards science and careers in science.

Key articles on Motivation and Interest

According to Schiefele (2009, p. 179): "Motivation is commonly understood as the state of wanting to perform a specific activity in a given situation (e.g., Schunk et al., 2008; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006)." Schiefele also makes a distinction between motivation and interest: "Interest represents a possible antecedent of motivation". (2009, p.179). This section looks at the literature on both motivation and interest, in particular the distinctions that have an important bearing on MultiCO methodology. Concerning the measurement of interest, a review article from Renninger & Hidi 2011 makes an important point: "Although researchers' questions should drive research on interest, their conceptualization of interest should inform their choice of measures. In addition, research addressing the ways in which interest might be generated and/or supported to develop should be aligned with both the conceptualization and measurement of interest." (p. 180)

The early work of Krapp (2002; 2005) on Self Determination Theory/Basic needs (for competence, autonomy, and social relatedness) has fundamental principles from which MultiCO has drawn a basis for the focus on interest. For example, Krapp (2002) , argues that it would be fruitful to consider the concept of basic needs, "which means that the emotional characteristics of an interest-based action would be experienced positively because the action satisfies basic needs such as those proposed by SDT" (p. 414). Krapp elaborates further: "The functional model of interest genesis postulates that the control of single interest actions and, on a long-term basis, the facilitation of interest development takes place on two different levels of information processing: in the conscious-reflective level concerning decisions about future learning goals and the emotional level which provides continuous and often non conscious feedback about the quality and/or efficacy of the ongoing action. Here, experiences referring to the fulfilment of the three basic needs discussed in SDT play a crucial role." (p.421).

Further quotations from Krapp's later work (2005) provide insights into interest and motivation that have informed MultiCO thinking: "From the perspective of the "person-object-theory of interest" the development of interest and interest-related motivational orientations can be explained at the level of functional principles by referring to a dual regulation system that consists of both, cognitive-rational and partly subconscious emo-

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tional control mechanisms. Within this regulation system, emotional experiences related to the fulfilment of three basic needs (competence, autonomy, and relatedness) are presumed to play a crucial role." (p. 381).

Krapp and Prenzel (2011) draw on this body of previous work when making a distinction between individual interest and situational interest; the emergence and impact of interest can be examined on different levels of analysis. On the first level, interest refers to the dispositional (or 'habitual') motivational structure of an individual. Here, interest is interpreted as a relatively stable tendency to occupy oneself with an object of interest. On this level, one usually speaks of individual interest. On the second level, interest refers to current engagements. It describes a state or an ongoing process during an actual interest-based activity. This is the case when we observe the learning behaviour of a student and characterise his or her motivational state as 'being interested'. This psychological state involves focused attention, increased cognitive functioning, persistence, and affective involvement. An actually 'operating' interest can either be caused by an already existing dispositional (individual) interest or by the special conditions of a teaching or learning or work situation (interestingness). An interest that is primarily caused by external factors is called a situational interest (Hidi, 1990). It may be transitory or may provide the basis of a longer-lasting interest (Hidi & Renninger, 2006; Krapp, 2002b). Krapp and Prenzel (2011) point out that more domain specific interest measures are less frequently used. They discuss at length the issues pertaining to domain specific interest measures, and describe an example of a differentiated instrument used for a study in physics, which included three dimensions: topics, contexts and activities – within which were eight topic categories, seven context areas and four kinds of activity, in all, 88 items. Factor analysis could then determine the construct of 'interest in physics'. This kind of breakdown of what the interest is about can enrich studies that look at specific subjects/domains of science and environmental factors.

Krapp and Prenzel review other research approaches for studying interest, including observations, interviews and databanks available on the internet. They question the theoretical and practical relevance of how these trends are measured and judged, as they do not provide an insight into interest development in specific sub groups or subjects. These authors call for a more exact analysis of data from longitudinal studies. They report on one such study in physics that demonstrated that when physics is taught so that students can recognize a direct connection to practical life situations then interest remains stable or increases.

Gender influences are complex, as personal attributes such as self-concept and self-efficacy are operating with environmental effects such as single sex schools or style of teaching. Krapp and Prenzel highlight the importance that such attributes play in explaining gender-specific differences in interest in science. With reference to international studies, Krapp and Prenzel report that differences between boys' and girls' interest in future careers in science are now only small. Moreover overall interest is more markedly different between less industrialised countries (where interest is higher for both males and females) and countries with advanced technological development.

Hiller (2011) presents a 5-stage-model of cognitive technology and science promotion that focuses on the development of motivation and interest:

- Awareness: first interest in technology

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- Openness: receptive to technological issues
- Involvement: development of initiative / intrinsic motivation
- Career options: promotion of talents, development of skills and self-concept (norms, attitudes, preferences, …)
- Choice: technology job orientation (job requirements and skills)

Technology literacy develops in a continuum between low and high subject-specific knowledge on the one hand and extrinsic to intrinsic motivation on the other.
Crucial for choosing a technology job (stage 5) is the alignment of self-concept (developed in stage 4) and the knowledge about job requirements and profile.
Important steps for the advancement of stages are repeated experiences of positive emotions during the engagement with technological phenomena. To achieve progress to each stage, specific interventions for students are continuously needed. These should comprise cognitive and manual approaches and the introduction of a role model. This enables the development of receptiveness to technological issues (stage 2), intrinsic motivation (stage 3), self-concepts, norms, attitudes and preferences (stage 4) and supplies information on job requirements and skills (stage 5).

Hiller's study comprised a meta-analysis of over 1000 projects (since 2008) on the promotion of technology and science related interest. The main focus was on early years' interventions, support of interested students, learning technology at school, gender-specific education, distinct contextual approaches, internet-based intervention as a medium for autodidactic learning and information source. The influence of these different interventions/methods was examined by quantitative and qualitative methods, investigating project leader experiences and projects' outcomes.

Most projects show a discrepancy between the goals and achievements, mainly because the projects target the development of interest but concentrate on 13-16 year old students who seem to be too old for the development of individual interests. At that age, also considering the imminent career choice, talent promotion instead of interest promotion should be intended. A clear separation between interest and talent promotion is recommended.

The best effects on talent promotion show programs based on an intensive exchange between students and professionals, supported by good additional material and well equipped classrooms. The intervention should give insights into working fields (e.g. via internships, specific school projects, inviting professionals to schools) and should clarify science's and technology's economical, cultural and social implications. Such interventions have the biggest effect not directly on career choices but on the students' ability to align their own self-concept and distinct job requirements (stage 4 & 5). These interventions should be initiated in 8th grade (14 year-old students).

Hiller's paper shows that informal learning approaches to promote technology and science related interests are often offered in form of a short contact with the issues, e.g. in a science centre. Research on educational neuroscience shows that this kind of learning is not suitable for sustainable interest development and the purpose of promoting career choices. Successive development of individual learning processes cannot be initiated by a single event. Nevertheless, these short contact approaches can reach a lot of people

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and can initiate first interest (stage 1: awareness). If an informal learning situation involves professionals who give information and guidance, progress of cognitive processes can be achieved. Additionally, preparation and follow-up in school is necessary to improve interest in science and technology. The best chance of success includes informal, co-constructive approaches organised in phases. However, further research is needed on this aspect.

To develop sustainable interest in science and technology and to stimulate creativity, social skills and linguistic competences, Hiller observes that first interventions should take place in kindergarten or early years of primary education and should be kept up continuously up to university. In early years' interventions, girls are as perceptive on science and technology related topics as boys. However, girls are less supported in technology and science related skills at home. Interventions on promoting science and technology interest have a significantly higher effect on females. Career- or study choices of female students are more influenced by social attitudes (own contribution to society's prosperity, support other people, protect the environment) than of male students. Mono-educative interventions should be preferred. Prejudices regarding girls' poorer scientific and technological competences are a social and societal artefact.

Finally Hiller points out that in addition to formal or informal interventions, an autodidactic internet-based information source should be implemented to illustrate the real variety of science and technology related careers and jobs and to offer further information.

A different focus on promoting motivation and interest in science is taken by Abrahams (2009) who reports on a study on the possible affective outcomes – emotions and feelings towards science – of practical work in science for Key Stage 3 (11- 14 years) and Key Stage 4 (15 – 16 years).

Abrahams notes that practical work is seen by teachers as central to the appeal of science and is a preferred method of teaching among students. However, students' attitudes towards science tend to decline as they get older and indeed the numbers of students choosing to study what are considered the most practical, chemistry and physics, are also in decline.

Abrahams emphasizes the differences between interest and motivation and indicates how confusion between these terms has often been represented in previous literature. He notes how practical work is likely to promote short-term interest in science as opposed to motivation to choose to study after compulsory education. He, like Krapp and Prenzel (2011) distinguishes the differences between personal interest (that which is beyond a teacher's influence) and situated interest (that which a teacher may influence). He also warns that although interest may be expressed by students and teachers regarding practical work it does not necessarily relate to any cognitive engagement with a practical nor the science involved.

Abrahams is critical of previous studies than only use one mode of data collection, i.e. questionnaires or interviews, and instead explains that this study involved 25 case studies using observations of actual practice in schools and was supported by interviews. A

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broad representation of English secondary schools took part in the study including urban and rural schools and did not involve observation of any practical activities that were conducted for the purposes of national assessment. The study involved teacher interviews before and after the lessons where learning objectives and reflections were discussed, student responses during and after lessons were recorded as well as field notes taken during the lessons.

Abrahams found that Year 7 students (age 11) liked practical work but older students generally preferred doing practical work rather than other forms of activity in science rather than liking practical work. The reason for the Year 7 view of practical work is that the students are introduced to novel scientific equipment and activities. The study found that there was a decline in interest amongst older students, as found in similar studies, and the fact that there was no longevity of interest would mean that it is situated interest rather than personal interest and that teachers' suggestions that students become motivated by practical work are misplaced and it is rather that situational interest is heightened by practical work.

Responses from teachers implied a belief that students often prefer practical activities as the activities require less effort from the students and the students do less work. Indeed, it was found from student responses that few students felt that practical work helped them to learn science. The author concludes that liking practical work declines in the early years of secondary school as the novelty factor of being in a science lab wears off. Situated interest amongst students may be sustained in lessons with regular practical work however, teachers often use practical work as a coping mechanism to sustain some forms of interest without seeing practical work as an opportunity to learn science.

A focus on motivation and interest that also included a distinction about kinds of interest, was found in Walper et al.'s (2014) longitudinal study in Germany to find out how students' physics-related interests change while progressing from primary to secondary school. In addition, they wanted to identify instructional practices that are perceived as promoting or as hindering students' interests in physics-related school subjects. Interest is defined in this study as a specific relationship between a person and an object. This relation is characterized by feeling-related and value-related valences as well as a cognitive-epistemic component. Two types of interest are distinguished: The relatively stable individual interest as well as the situational interest that is defined as a state that is primarily caused by external factors of a specific situation. This refers to the same basic concept of interest that has been presented by Krapp and Prenzel (2011), that is, the "Person-Object-Theory of Interest"; it is also the concept that we are using in MultiCO and in the design of the pre-/post questionnaire

The study comprises surveys from grade 4 (last year at Primary School, student age 10) to the 7th grade. 348 students were questioned about their situational interest in physics-related school subjects and their individual interest in physics.

Once a year, these students completed a questionnaire. Both the individual interest and the situational interest scale had already been developed in a previous cross-sectional part of the study. They consist of five to six items (rated on a four-point Likert-scale). In addition, semi-structured interviews with 18 members of the quantitative

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sample (8 girls and 10 boys that mainly showed a decrease in their situational interest) were conducted at the end of 6th grade to identify instructional practices that influence students' interests in a positive or a negative way while progressing from primary to secondary school. The quantitative data show that on average students' physics-related situational and individual interests decline strongly from fourth to seventh grade.

The qualitative results indicate that students' practical activities influence their interest in physics-related instruction positively because they provide an opportunity to act and think autonomously. Also, references to everyday-life experiences and instructional practices ensuring an appropriate level of difficulty of physics instruction seemed to promote students' interests. In contrast, repetitions, note-taking and most of written exercises were perceived as uninteresting and boring. Furthermore, the students described both excessive demands as well as an individually perceived pressure to perform as hindering for their interest development.
However, those very features as well as lots of written exercises were perceived as characteristic for physics instruction in secondary school. By comparison, within their physics-instruction in primary school, just a few students experienced these instructional practices.

Another study by Basl (2011) was conducted to identify potential causes of the relatively low interest among 15-year-old Czech students in further science-related education and careers. The focus was on the impact of parents and schools.

The situation in Czech Republic was compared to three countries:
Germany (PISA proficiency levels, science literacy achievements: proportion of high-achieving students is similar to the Czech Republic),
Finland (proportion of high-achievers higher than in Czech Republic) and
Norway (proportion of high-achievers is lower than in Czech Republic).

On the dataset of the PISA 2006 survey analyses were performed on the individual student level using correlation analysis, linear regression modelling and structural equitation modelling.

Results show that the impact of family background on future science-related study and/or career has not been demonstrated by the analyses. However, the findings show a fairly strong influence of the school: The interest in future careers is significantly influenced by the degree to which school prepares students for future education and careers. School also influences the level of awareness of science-related career opportunities, being crucial for interest. In general, the influence that a school may have on students and activities that schools can develop are both seen as more effective indicators of future science career aspirations than the occupational status and education levels of parents.

Swarat et al. (2012, p. 515) highlight the problem through this quotation: "With much evidence supporting the positive impact of interest on a variety of learning outcomes (Krapp, Hidi, & Renninger, 1992; Schiefele, Krapp, & Winteler, 1992), it is reasonable to suggest that the lack of interest among young students not only threatens the production of the next generation of scientists, but more importantly, impedes students from becoming scientifically literate citizens, as they are unlikely or even unable to engage

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with important science-related societal issues…. Faced with this problem, researchers have sought to identify sources of student interest, or ways of fostering interest." This point is a useful basis for our studies in MultiCO.

Swarat et al. (2012) remind us that school science consists of different elements (e.g., topic, activity, learning goal) and that the students' interest might be a reaction to a combination of these elements. Research examining interest will therefore have to take into account not only content topics to be learnt but also the activities through which these topics are learned. Swarat and co-authors (2012) refer to Haussler's model (Haussler, 1987) that breaks down "interest in physics" into three aspects: interest in a particular subject matter; interest in a particular context in which the topic is presented; and interest in the particular activity format through which one is engaged with the topic. Swarat et al. (2012) confirm that interest in science is largely determined by the type of activity and less by the content topic. Within the different activity types tested, hands-on activities and those that involved the use of scientific instruments or technology triggered significantly more interest than activities that were purely cognitive or less physically engaging. However, it has been pointed out that integrating technology does not automatically foster interest development but that further considerations should be given to how to use technology effectively (e.g. promoting a sense of authenticity and connecting students with real data). In conclusion, Swarat et al (2012) recommend exploring ways of effectively sequencing activities, choosing adequate activity forms for different materials and learning goals, and appropriate activities for different student populations.

Synthesis and implications for interventions

As Christidou (2011) points out, students' low interest in science and their relatively negative attitudes can be – at least in part – traced back to the way science is taught in school. Christidou's analysis shows that teachers themselves need to have a positive stance towards science and scientists in order to inspire their students. This is in accordance with Osborne et. al (2003) who found that the most significant determinant of attitude to school science is classroom environment and in particular quality of science teaching. "Good teaching was characterized by teachers being enthusiastic about their subject, setting it in everyday contexts, and running well-ordered and stimulating science lesson…. talking with the students about science, careers and individual problems" (p. 1068). Nevertheless, in schools, science is often presented in a decontextualized way, not relating to everyday life, and the academic, strongly intellectual and abstract character of science is emphasized (Christidou, 2011; Walper et al., 2014). Therefore, students view science as a cluster of concepts and facts to be "learnt", above moral and human values and without any opportunities for creative expression, far away from society. In addition, school science often reinforces stereotypes (e.g. images of scientists) and fails to eliminate barriers to women in science (Christidou, 2011). However, such stereotypic and gender biased images are also nourished by popular science. School science and teachers, as well as popular science are therefore considered as important factors determining students' voices (Christidou, 2011).

Conclusions about the influence of schools are in accordance with results from Basl (2011), who used the PISA 2006 data set for his analyses. The data show no significant influence of family background but significant impact of school: Interest in science and

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future careers is influenced by the degree to which school prepares students for future education and careers and creates awareness of science-related career opportunities. School science – to be successful in fostering interest – should incorporate affective aims in the curricula and take into account fields and topics of students' interest in contexts of personal and everyday relevance, such as health or environmental issues (Christidou, 2011). This is in accordance with Krapp & Prenzel (2011) who report on a study in physics that demonstrated that when physics is taught so that students can recognize a direct connection to practical life situations then interest remains stable or increases. Likewise Potvin & Hasni (2014) conclude from their review of nine articles that contextualization interventions have positive effects on interest, motivation and attitudes.

In relation to school science teaching approaches, methods and types of activity, also Abrahams (2009) found that situational interest in science is heightened by practical work due to the introduction of novel scientific equipment and being an alternative to other non-practical teaching methods. Like Swarat et al. (2012) and Walper et al. (2014), he showed that students see practical work as preferable to non-practical activities such as writing. However, Abrahams observed that this affective outcome does not necessarily relate to any cognitive engagement, to any longer-lasting (individual) interest or to the intention of pursuing science in post compulsion (Abrahams, 2009). Also Toplis (2012) states that practical work remains a complex issue and needs further evaluation about its effectiveness in supporting real science learning (e.g. fostering conceptual understanding and practical inquiry skills). Potvin & Hasni (2014) conclude from an extensive literature review that 'hands-on' activities, which do not require much reflection, do not have positive effects on students' interest, motivation and attitudes whereas 'inquiry-based' or 'problem-based' interventions seem to have positive effects.

Christidou (2011) also points out that inquiry-based and issue-oriented learning have been demonstrated by various studies to instigate positive attitudes and interest towards science. One of the reasons seems to be that such learning provides opportunities to act and think autonomously (Walper et al., 2014). As part of their self-directed learning, Hiller (2011) postulates that students should be more involved in planning and developing learning environments and materials. Collaborative work also seems to have positive results on students' interest, motivation and attitudes (Potvin & Hasni, 2014).

Christidou (2011) recommends the involvement in informal out-of-school science activities as it may be associated with a firmer commitment to science and science learning and the development of more scientifically literate adults. Hiller (2011) points out that such activities have indeed a positive effect on short-term science interest (e.g. fun, curiosity). However, professional guidance and support is needed during out-of-school science activities as well as preparation and follow-up in school to foster cognitive engagement and a longer-lasting interest in science. School is still seen as the main place for technology/science education, and educational programs have to start early. They should take place continuously from Kindergarten to University and have to be adapted to the skills and needs of each specific age group (e.g. from Co-construction to self-directed learning).

Another intervention that has been proved successful in fostering interest, motivation and attitudes as well as careers in science and technology, especially with girls, is the

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contact with role models (Potvin & Hasni, 2014). As the girls' job choice is strongly influenced by social factors (e.g. wanting to help others or protect the environment), economical, social and cultural risks and chances should be part of the learning programs in technology education (Hiller, 2011). In addition, gender sensitive programs or specific programs for girls are advocated to foster girls' skills in technology that are less often promoted in their families (Hiller, 2011).

In explaining gender-specific differences in science interest, Krapp & Prenzel (2011) highlight the importance of personal attributes, such as self-concept and self-efficacy, together with environmental effects such as single sex schools or style of teaching. However, with reference to international studies, they report that differences between boys' and girls' interest in future careers in science are now only small.

The important role of students' feelings of enjoyment and self-efficacy in science are nevertheless pointed out by Barmby et al. (2008) who argued that students should be enjoying the experience that they are having in the classroom if we want them to eventually consider studies or careers in science. Potvin and Hasni (2014) have also observed that self-efficacy is linked to declared interest: Students who choose to pursue a career in science and technology are those who have good self-esteem or consider themselves as good achievers. Hence, it is important to develop students' feelings of self-efficacy in science and technology courses.

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2.1.3 Activities for promoting STEM careers (Task 2.5, led by UT)

Introduction and overview

This section focuses on studies that have provided insights into specific activities that promote science careers. The origin of the problem of lack of student interest or motivation, particularly in secondary science education, is seen to lie in pedagogical considerations (Potvin &Hasni, 2014). To counteract this, a range of educational considerations has been introduced. A major development, designed to attract young people to science studies and to raise scientific literacy among future citizens, has been to view science education as being 'education through the context of science' (European Commission 2004; 2007; 2009; 2012). Research has shown that context-based approaches in science education result in improvements in attitudes towards science (Bennett, Lubben, & Hogarth, 2006) and may lead to a higher interest in science-related careers (Reid &Skryabina, 2002). Teaching strategies that actively engage students in the learning process, such as through scientific investigations, increase conceptual understanding and also have positive effects on students' attitudes towards science (Minner, Levy, Century, 2010; Potvin &Hasni, 2014). Culturally responsive teaching, by taking into consideration students' ideas and indigenous knowledge (Hernandez, Morales, & Shroyer, 2013), also attracts students to study school science.

A systematic analysis of a selection of articles shows that interventions could be divided into 3 broad categories, which are described later. Further details of this systematic review and analysis are found later in this section, and in Appendix 1. First, some reviews of key articles in this area are presented.

Key articles on activities

Bennett, J., Lubben, F. & Hogarth, S. (2006) review the detailed research evidence from 17 experimental studies undertaken in eight different countries on the effect of context-based and science technology and society approaches (CBA and STS), drawing on the findings of systematic reviews of the research literature. The review findings indicate that these approaches result in improved attitudes to science compared to conventional approaches.

The authors pose the question: Does teaching science in context improve school students' attitudes to science? Definitions used in the paper are:
"CBA are approaches adopted in science teaching where contexts and applications of science are used as the starting point for the development of scientific ideas. This contrasts with more traditional approaches that cover scientific ideas first, before looking at applications" (p. 348). One aim underpinning such approaches lies in affective responses – how students feel about science experiences. The authors point out that through addressing students' affective response to science, students' interest will encourage them to study science subjects beyond compulsory education.

The paper reports on different kinds of interventions, including courses of duration at least one year, and shorter interventions. What might be of interest are the evaluations. These are tabulated on pages 358-361. Some evaluations include attitude scales, most studies are pre- 2000 but there may be some useful ideas regarding instruments. The

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authors summarise the evidence regarding attitudes on page 363. These come from nine studies, one of high quality, three of medium high quality, five of medium quality. Seven studies report evidence that context-based approaches improve attitudes. Three studies collected data relating to subject choice. Barber (2000) found more students taking Salters Advanced Chemistry went on to study chemistry, Smith and Matthews (2000) increasing numbers in physics and biology from STS courses. Ramsden (1997) found "more positive responses to a context-based approach in lessons were not translated into increased interest in careers involving science" (p 364). So there is mixed evidence on the impact of context-based/STS approaches on subject and career choices.

Dabney *et al*. (2011) show that taking part in science related activities does have a major role in choosing science related careers. For promoting STEM careers and also engagement and interest in school and school science, varied methods have been used in different studies. The authors investigated the effect of out-of-school time (OST) science activities on STEM career interest in universities. OST activities are defined as one the one hand participation in science groups, camps, clubs or competitions and on the other hand reading or watching non-fiction science or science-fiction. Hobbies were not separately examined. The study uses data from the "Persistence Research in Science and Engineering Survey (PRiSE)" (n=6882; students from the USA in their first year at university).

The results show that 6.4% of the PRiSE respondents has participated in OST science activities (OST clubs/competitions or reading/watching science activities) at least once per year (93.6% rarely or never participated). These participants had significantly higher career interest in STEM at university. OST had significant effect on STEM career interest, but demographic and background variables have even higher influence (gender, middle school interest and grades in science/mathematics, higher socioeconomic status). A significant interaction between socioeconomic status and participation in OST science clubs/competitions was found.

In discussion, Dabney et al point out that participation in OST activities has a strong positive association with the selection of a STEM-related career. A clear signal for the influence of voluntary and individual-directed OST activity is reading/watching non-fiction science and science-fiction which had a significant effect on students' STEM career interest. This indicates the potential for integrating these activities also in school. Regarding the socioeconomic and gender gap, an improved access to OST activities is more important for females and students with a low economic status to foster their STEM interest. One solution can be the strengthening of the connection between OST programs and schools.

A paper by Minner et al (2010) presents a synthesis of the findings from research (meta-analysis) conducted between 1984 and 2002 and focuses on the impact of inquiry science instruction on K–12 student outcomes. To address their research question, the authors developed a conceptual framework that specifies what is meant by "inquiry-based science instruction". Also, the researchers used a mixed-methodology approach to analyse numerical and text data as to describe the impact of instruction on K–12 student science conceptual learning.

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The project included three phases: Phase I - Report Collection, Phase II - Study Coding and Phase III – Analysis and Dissemination. During Phase II, the conceptual framework was developed in which inquiry science instruction is characterized as having three aspects: the presence of science content (science as inquiry, life science, physical science and earth-space science), student engagement with science content, and student responsibility for learning (student's role as a learner), student active thinking, or student motivation within at least one component of instruction (question, design, data, conclusion, or communication). Student outcomes were also been coded in six different types: student understanding of science concepts, facts, and principles or theories; and student retention (a minimum of 2 weeks after treatment) of their understanding of science concepts, facts, and principles or theories. As far as the methodology is concerned, three research designs were used: experimental, quasi-experimental, and non-experimental. In each case, a coding protocol was developed to enable analysis of a variety of research designs and types of data.

Overall, as Minner et al (2010) report, there is no evidence of strong positive effects of inquiry-based instruction in their synthesis. Nevertheless, there is an overall finding that shows an increase in students' science conceptual understanding during the investigation process in inquiry science instruction. More specifically, Minner et al (2010) refer to students' active thinking, engagement in the investigation process and hands-on experiences with physical phenomena associated with increased conceptual learning in contrast to the passive teaching strategies used by the teachers. Concerning the student outcomes, high levels of inquiry saturation (the amount of inquiry) in instruction have shown moderate results suggesting that future research may explore these associations both in terms of conceptual learning as well as other kinds of student outcomes.

Welch and Huffman (2011) report on a robotics program FIRST (FIRST: for inspiration and recognition of science and technology), which is a six week long program designed to inspire students in mathematics, science and technology and to increase their interest in these fields. The program is characterised by the combination of engineering and technology in a context- and project-based learning experience. The program is organised by a teacher and a scientific mentor from the university or local (industry) company. The task is to design a robot for a specific purpose. The program, being organised as a competition, follows the ideas of constructivism and project-based learning with the use of hands-on objects, real-life orientation and problem-solving challenges.

Welch and Huffman's study included one intervention group (n=58) and one control group (n=41; no robotic program), who were compared in a pre-/post-test design using TOSRA (test of science-related attitudes) to assess seven dimensions of student's attitudes towards science:

- Social implications of science
- Normality of scientists
- Attitude towards science inquiry
- Adoption of scientific attitudes
- Enjoyment of science lessons
- Leisure interest in science
- Career interest in science

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The results show that dimensions1,2,3 & 4 showed significantly higher values in the intervention group. The biggest effect was measured for 4 and 1. Hypotheses for higher values of social implications of science included:

- Collaboration with scientific mentor
- First experience of self-organised experiments
- First experience of applying skills learned in school

Regarding normality of scientists, hypotheses included:

- Shift in viewpoint toward scientists
- Positive change of connotation of the often used term “geek”

For science inquiry the authors suggest that challenge-based inquiry stimulates open-minded and creative thinking, gathering and evaluating of information to be used for concrete problem-solving, the ability to come to a decision, designing a prototype, testing and evaluation and redesigning as an iterative process and as a problem-solving method is introduced as a matter of course. Adoption of scientific attitudes involves appropriate presentation of own ideas followed by discussion, and a willingness to reverse opinions as a necessary process in science.

Archer, DeWitt and Dillon (2014) present findings from an intense six-week pilot STEM careers intervention programme combining multiple activities. The programme aimed to raise awareness of a range of STEM careers; provide practical experiences of the kinds od work undertaken by STEM professionals; enable students to meet some STEM practitioners and carry out extended STEM project work with a multidisciplinary focus.

The programme activities for students aged 13-14 included: two school visits/excursions (to the Centre of the Cell, a small science centre, and the Big Bang Fair, a large STEM conference); visits from 7 STEM Ambassadors; and a visit from a researcher in residence. Other visitors were STEM professionals from different fields and they participated in a networking event (groups of students spent 15-20 minutes with each of six different STEM professionals, learning about the person and their job). This event had follow-up activity in which students followed through with in-depth research about one are which interested them. Activities also included a session presented by a STEM road-show, participation in a Prince’s School of Traditional Arts “Maths/Textiles Project” and a series of six teacher-led sessions that were developed to broaden students’ perceptions of individuals and jobs in STEM.

This study used pre- and post-intervention surveys (68 students), classroom observations of intervention activities, three post-intervention discussion groups (5 or 6 girls per group) and a post-intervention interview with the lead teacher. The pre-intervention questionnaire contained items focusing on aspirations in science, attitudes to school science, (perceived) parental attitudes to science, participation in science related activities outside school, self-concept in science, peer attitudes to school and to science and perceptions of scientists. At the end students were asked to list as many jobs as they think of that used science. The post-questionnaire was similar (items related to participation in science related activities and perceived parental attitudes were removed as they were not expected to change). Three discussion groups (lasted 30-40 minutes) were formed six months after the intervention (each group contained five or six students).

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Groups focused on students' overall impressions, their perceived learning (including about STEM careers) and attitudes to STEM careers. Two classroom lessons were observed: introduction to STEM careers and highlighting the role of science within non-STEM careers.

The intervention did not significantly change students' aspirations or views of science. Despite this, it did appear to have a positive effect on broadening students' understanding of the range of jobs that science can lead to or be useful for. Students' aspirations may be extremely resistant to change, but students' understanding of "where science can lead" may change during the intervention. It is important to understand that science is useful for careers in and beyond science, at degree and technical levels.

Implications from this study are:

- It could be more productive to integrate "fun" activities with "normal" lessons, rather than running them as standalones.
- It is important to ensure a balance between promoting graduate and non-graduate careers, careers in and from STEM.
- It is productive to ensure that all activities in a programme provide opportunities for consolidation and reflection.

Another study by Hernandez et al (2013) proposes a model of culturally responsive teaching for the preparation and assessment of science and mathematics teacher candidates, focusing on the process and outcomes of the theoretical research. More specifically, the research questions concern the characteristics of culturally responsive teaching and the characteristics and behaviors of teacher while applying such teaching. The developing process of this model refers to 3 steps: comprehensive review of literature, synthesis of literature into thematic categories, and piloting of thematic categories in a critical approach to provide exemplars of behavior in each category. Regarding the piloting phase, a qualitative case study was conducted involving 12 CLD (culturally, linguistically diverse) individual non-traditional Latino/a students participating in a funded scholarship teacher education program. The thematic categories emerging from the analysis that define culturally responsive teaching are as follows:

1. Content integration: inclusion of content from many countries, fostering of positive teacher-student relationships, high expectations for all students.
2. Facilitation of knowledge construction: teacher's ability to build on what students know as they assist them in being critical and independent thinkers
3. Prejudice reduction: teacher's ability to use a contextual factors approach to build a positive safe classroom environment free of prejudices.
4. Social justice: teacher's willingness to act as "agent of change" while aiding students to develop sociopolitical or critical consciousness.
5. Academic development: teacher's ability to create opportunities in the classroom that aid all students to achieve academic success and use of research-based instructional strategies according to the needs of the diverse background and learning styles.

According to these researchers, evidence indicates that the teacher candidates have succeeded in demonstrating all the thematic categories, though it was difficult to find evidence related to social justice. As Hernandez, Morales and Shroyer (2013) argue, cul-

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turally responsive teaching allows students to link their daily experiences to school curriculum, particularly in science and mathematics, thus making teaching more effective. Hence, they suggest that teacher education programs must bring this approach to the forefront developing strategies such as this model to effectively address the needs of diverse learners.

Systematic review of articles

A further systematic review in this aspect was undertaken to scope the field more widely, and involved an article search which was based on a research question:
What science related career/industry activities have been researched and what have been the measured outcomes?
For searching articles, the following search engines were used: EBSCO Discovery; Taylor & Francis Online; Scopus; Web of Science.

Inclusion terms that were used in the search were:

- Motivating youth science career
- Industry partnership programs
- School science activities linked to industry
- Young people in science activities linked to industry/career
- Science- related career interventions
- Science-related industry intervention
- Career-related science teaching
- Out-of-school industry visits in science
- Science related career awareness

Exclusion criteria were:
Above school level articles (K-12): college, undergraduates, university, PhD, higher education

- Intervention not done and impact of the intervention not studied
- Survey articles of science careers, students interest for science related careers
- Does not fit into the time frame: 2000-2015

The search resulted in 17 articles, which were then analyzed. Further reading showed that 7 articles did not fit the research question, because they: did not have an intervention, hence which impact was being measured; had an intervention, but no impact was measured; lacked description of impact measure methodology and therefore did not produce reliable results; focused on Science and Mathematics teacher education, and no impact on school students were analyzed.

Therefore 10 research articles were used to analyze under the following aspects, which are presented in Appendix 1:

- What kind of STEM related intervention method was used?
- How was the effect of intervention impact measured?
- What were the measured outcomes?

Summary of STEM career related interventions

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According to Dabney *et al*. (2011) these college students, who had reported of having participated in science related after-school activities like science groups, camps, clubs, competitions, reading/ watching non-fiction science, science-fiction books/ movies at least couple of times a year during middle and high school years, were more likely to report interest in STEM careers. Therefore taking part of science related activities do have a major roll, in choosing science related careers in the future.

For promoting STEM careers and also engagement and interest in school and school science, varied methods were used in different subjects. Analysis of the articles showed that, the interventions which were used, could be divided into 3 broad categories: out-of-school activities like visiting science centers (Archer *et al.*, 2014; Jarvis & Pell, 2002; Chapin *et al.* 2015), science related companies (Gebbles, Evans & Delany, 2011), other science related facilities like greenhouse, blood bank (Muscat & Pace, 2013), camps/ workshops (Chapin *et al.* 2015) and also field work (Gebbles, Evans & Delany, 2011). Authors of these articles in this category did emphasize the need to give students the experience of authentic settings of action, that classroom teaching lacks and furthermore giving students possibility to participate in activities that the specialists working on a specific field would experience.

The second category for listing activities would be STEM related after-school programs like science clubs (Mey *et al.* 2014; Welch & Huffman, 2011). Like pointed out by the authors, science clubs are voluntary, chosen by students, who are already interested in the activities of "science clubs". One could recognize the aim to introduce one specific area connected to science and with that reassure the new generation of scientists in specific field (Mey *et al.* 2014; Welch & Huffman, 2011).

The third category of activities would be STEM-career interventions combined with curriculum teaching (Archer *et al.*, 2014; Gould, Dussault & Sadler, 2007; Muscat & Pace, 2013; Orthner *et al.,* 2013). In one case the intervention of visiting blood bank and greenhouse in Muscat & Pace (2013) was meant to complement understanding of the topics learnt at school (blood circulation system and photosynthesis), but took place outside the school building. It is necessary to stress that in the case of Orthner *et al.* (2013) only small changes were made in the way core subjects, including science, were taught in middle school (6^{th}-8^{th} grade). More specifically career-related examples illustrated the value of learning the topics covered according to curriculum. In the case of computer science, in Ernst & Clark (2012), virtual school students had a task to develop a computer game by themselves, illustrating the possible career as a computer scientist and computer game developer. One innovative teaching tool to use in Astronomy, would be online telescopes, which are easily accessible for everyone and enable students to solve problems, presented in research projects, which students can take up.

Depending on what was intended to be affected with the intervention, instruments and research design varied. Majority of the articles did measure the impact on knowledge gains, with using written pre- and post- test design (Gould, Dussault & Sadler, 2007; Jarvis & Pell, 2002; Muscat & Pace, 2013) or testing students' knowledge after the intervention (Ernst & Clark, 2012; Mey, *et al.*, 2014). Different attitudinal aspects were measured. Some articles did incorporate aspects of scientists' image among students (Archer *et al.*,2014), science related industry image in the eyes of students (Gebbles, Evans & Delany, 2011), students' aspirations to choose STEM career (Dabney *et al.*,

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2011; Archer *et al.*, 2014; Jarvis & Pell, 2002; Welch & Huffman, 2011), attitude toward school science (Archer *et al.*, 2014; Jarvis & Pell, 2002), students self-concept in science (Archer *et al.*, 2014). To support their initial findings, group interviews were used by Archer *et al.* (2014) six months after STEM week activities to determine overall impressions, recollection of STEM week's activities (what enjoyed and what not), whether anything was learnt (also about careers in STEM); whether students had recognized the connection with STEM careers; whether they felt change in attitudes toward STEM careers. Muscat & Pace, 2013 used classroom discussions and pre- and post-intervention interviews with four students were carried through.

Longitudinal effects of used intervention were measured by Archer *et al.* (2014) six months after the STEM activity week. Jarvis & Pell (2002) also measured longitudinal effects of visiting space center two months after visit and six months after visit. But other studies did not measure longitudinal effects, but did bring out the need to study longitudinal effect on students.

Analysis of research outcomes showed that although the interventions that were used, were meant to raise students' interest for STEM related careers, using questionnaires, did not identify positive impact on students choice of STEM related careers, but positive attitude and students' knowledge gains about possible careers connected to science came out in interviewing students (Archer *et al.*, 2014). In Jarvis & Pell (2002) authors did detect positive impact of space centers' visit on students' aspiration to become a scientist, but the excitement dropped among girls after four months had passed from the visit. This supports the need to measure longitudinal effects of interventions aiming to raise students' interest in choosing a STEM related career. Interestingly some articles presented information of students' decision to choose STEM related career or to study connected field further in college, although not directly focused or measured (Ernst & Clark, 2012; Gould, Dussault & Sadler, 2007; Chapin *et al.*, 2015) showing that giving students possibility to participate in authentic science related activities, can lead students to choose STEM related career. Additionally as shown by Orthner *et al.* (2013) implementing STEM career related examples in teaching core curriculum can have positive effect on students' engagement and value for school, without making drastic changes in teaching methodology. Gains in knowledge was achieved and reported in all the articles that measured it. Metacognitive and cognitive gains were measured only by Muscat & Pace, 2013 by using Vee-diagrams and concept maps and showed that visiting greenhouse and blood bank helped to build new connections between concepts, and also resolve misconceptions. Therefore in order to study metacognitive gains during intervention, concept maps and Vee-diagrams could serve as useful instruments.

See Appendix 2 for a more detailed mapping of key articles in this aspect of the conceptual framework.

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2.1.4 Counselling for STEM careers (Task 2.4 led by UEF)

Introduction and overview

There are few studies concerning counselling on science-based careers in the literature, however those that exist provide insights into counselling issues relevant to MultiCO. Brouzos *et al.* (2015) studied counselling needs of a sample of secondary school students in Greece. The effect of age, gender, and academic performance on such perceived counselling needs was also investigated. An exploratory factor analysis yielded five factors: learning skills, vocational guidance/development, interpersonal relationships, personal development, and social values. These findings corroborate earlier research suggesting that adolescents express concerns regarding academic, career, personal, family, and interpersonal issues. The study also demonstrated that students were more likely to prioritize their counselling needs in the following order: social values (e.g., being helpful to others, managing negative peer pressure, etc.), learning skills, vocational guidance/development, interpersonal relationships, and, lastly, personal development. The study revealed that issues related to social values, such as learning how to be of help to others and how to manage negative peer pressure, were particularly important for Greek adolescents. A secondary purpose of the study was to investigate the differential effects of demographic variables on students' perceived counselling needs. The results indicated that Greek students' counselling needs varied as a result of gender, grade level, and academic performance. Female students expressed higher needs for counselling support in all areas compared to males. These differences may simply reflect differences in the socialization of girls and boys, which typically result in girls being less reticent about admitting their difficulties compared to boys.

Aspden *et al*. Sheridan (2015), determined the level of knowledge New Zealand secondary school career advisors had regarding the pharmacy profession, how they obtained knowledge of the profession, and their potential influence on students' decisions to study pharmacy. Several trends emerged. The first was that career advisors were most knowledgeable about basic community pharmacy roles, suggesting that career advisors are familiar with the traditional roles of a pharmacist. They were, however, less aware of pharmacists' roles in other settings. Career advisors can play an important role in students' career decisions and the information they provide to students can influence their potential career choices. One suggestion for improving the promotion of pharmacy within secondary schools was a greater involvement of pharmacists and pharmacy students in the promotion of pharmacy as a profession. Increasing contact from practicing pharmacists and undergraduate pharmacy students are potential ways of increasing student interest in pharmacy. The study indicated that almost two thirds of respondents had received requests about pharmacy as a career in the previous 5 years. Therefore, having accurate, informative resources about pharmacy courses and career paths easily accessible to career advisors is essential.

This NewZealand study showed that of the career advisors who received contact from universities, the most common form of contact was a prospectus. Advancements in information technology can also help school career advisors address the needs of students. Efficiently utilizing advancing technology such as credible websites and promotional videos combined with a proactive approach is considered an effective method to pro-

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vide career counseling services to students. Of interest were the responses to the question regarding the characteristics of students to whom career advisors would recommend pharmacy as a potential career choice. The most common characteristic was personal interest and/or strength in science, especially chemistry and biology. Other common characteristics were good social and communication skills, and academic and practical traits such as being highly organized and responsible.

A study by Obi (2015) of 50 undergraduate students to investigate the development of indecision, anxiety, uncertainty and insecurity concerning their career choice showed that constructionist interventions contribute to the major goal of career planning which are a sense of identity and meaningful vocational action. Schütte and Köller (2015) evaluated an intervention programme designed to increase secondary school students' motivation to pursue a science career. When the programme began, students who enrolled in the science elective were already substantially more motivated than their classmates. Offering such an intervention programme as an elective did not further increase the participating students' science motivation. It seems worthwhile to carry out intervention programmes with talented students who show (comparatively) little interest in science at the outset rather than with highly motivated students who self-select into the programme.

Key articles on counselling

Cleaves (2005) studied the formation of post-16 choices over 3 years among higher achieving students with respect to enrolment in post-compulsory science courses. Transcripts from four interviews carried out over 3 years with 72 secondary school students were qualitatively analysed. Students were found to shape their choices for science in a variety of ways across time. The situation regarding science choices hinges on far more dynamic considerations than the stereotypical image of the potential advanced science student, committed to becoming a scientist from an early age. There is an interplay of self-perception with respect to science, occupational images of working scientists, relationship with significant adults and perceptions of school science. Students who chose science post-16 were students with widely differing choice trajectories, the commonest of which was the student with a 'precipitating' trajectory. For those who chose science from the 'directed' group, sciences were needed for a specific career ambition, and in the 'partially resolved' group there was generally an interest in particular aspects of science, which was stronger than for other curriculum subjects. By focusing on the choice trajectories of individual students, it was found that particularly students with a 'funnelling identifier' trajectory eliminated the possibility of post-16 science on these bases. Among those students with a 'partially resolved' or 'funnelling identifier' trajectory the majority of students, including those who chose post-16 science, reported a lack of relevance in the way that science was taught in school.

The findings of earlier studies (Furlong and Biggart 1999, Stables 1996) were confirmed among students who did not choose science and who depicted a stereotypical view of scientists and science. They saw much of the science curriculum as irrelevant and, like students in deHart's (1998) study, thought that science teaching seemed to be limited to preparing students for a research career in science at the university level. This pointed to a need to broaden both the science curriculum and the students' views of science work as deHart (1998) recommended. He proposed that we integrate the world

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of work into science education, with particular emphasis on the evolutionary changes that are taking place in the world of science in relation to the development of the global economy and the information age. Munro and Elsom (2000) called for stronger links between science and careers departments to promote awareness of science-related opportunities.

Opinions about science in school or the school curriculum did not seem to be significant influences for many of the potential advanced science students in Cleaves' study. The majority of students who chose science, and particularly students with a 'precipitating' trajectory, were distinguished by their deeper appreciation of what one might expect in a science career, despite evidence that such understanding had not been acquired in the science classroom. The present research supports Coles' recommendation for scientific activity in appropriate balance so that young people have the opportunity to sample a mix of activities that working scientists carry out in their work.

Two other powerful factors militate against a post-16 science choice. The first is a lack of knowledge about science occupations and science work, particularly apparent among those who decide against taking science past the age of 16. The second is the effect of a self-perception among those students who envision their science ability to be much lower than their achievements would indicate. This helps to explain Rosser's (1995) finding that students do not see scientists as people they could grow up to be. What makes students choose science, other than reasons of interest and enjoyment, is their confidence in their own ability to do science as well as the association of good future career prospects, not necessarily science careers, with post-16 science courses or A-level sciences.

Brouzos, Vassilopoulos, Korfiati, and Baourda (2015) studied counselling needs of a sample of secondary school students in Greece. Moreover, the effect of age, gender, and academic performance on such perceived counselling needs was also investigated. The sample consisted of 931 students (433 girls and 498 boys) aged between 12 and 16 years old. A 70-item questionnaire was developed and administered to assess participants' perceived needs in various areas. The exploratory factor analysis yielded five factors: learning skills, vocational guidance/development, interpersonal relationships, personal development, and social values. These findings corroborate earlier research suggesting that adolescents express concerns regarding academic, career, personal, family, and interpersonal issues (Nyutu and Gysbers 2008; Owens et al. 2011; Yoo and Moon 2006; Yuen et al. 2010). The study also demonstrated that students were more likely to prioritize their counselling needs in the following order: social values (e.g., being helpful to others, managing negative peer pressure, etc.), learning skills, vocational guidance/development, interpersonal relationships, and, lastly, personal development. In contrast to the results reported by Sculli (2011), the study revealed that issues related to social values, such as learning how to be of help to others and how to manage negative peer pressure, were particularly important for Greek adolescents. Although this finding is compromised by the rather low internal reliability displayed by the social values factor - perhaps due to the small number of items included – it is still indicative of the issues that are of great concern to Greek teenagers of today. This result could possibly be explained by the increased importance of peers and the rise of peer pressure during early adolescence (Rice and Dolgin 2008). It could also be attributed to the transition from collectivistic to individualistic attitudes seemingly taking place in Greece

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(cf., Georgas 1989; Mylonas et al. 2006); a transition that has put a strain on typical social and personal values that Greeks used to cherish. That participants in the current study reported great need in learning how to help others overcome their personal, family, and social problems. As noted, secondary school students expressed a particular interest in receiving counselling support in the areas of social values, learning skills, and vocational guidance/development.

A secondary purpose of the study was to investigate the differential effects of demographic variables on students' perceived counselling needs. In line with previous studies (cf., Borgen and Hiebert 2006; Giovazolias et al. 2010; Güneri et al. 2003; Sculli 2011), the results indicated that Greek students' counselling needs varied as a result of gender, grade level, and academic performance. Interestingly, female students expressed higher needs for counselling support in all areas compared to males. These differences may simply reflect differences in the socialization of girls and boys, which typically result in girls being less reticent about admitting their difficulties compared to boys (Addis and Mahalik 2003; Giovazolias et al. 2010).

However, as it stands, counselling in Greek secondary schools remains limited and largely focused on career guidance and development (Brouzos 2010). What is more, such guidance is still offered mainly as a 'teaching subject' (i.e., as part of the curriculum that aims to provide somewhat superficial vocational information and advice to students). Borgen and Hiebert (2006) have advocated the need to move past advice and guidance for school students towards providing counselling services designed specifically to address their particular needs.

Berk, Muret-Wagstaff, Goyal, Joyal, Gordon, Faux, and Oriol (2014) reviewed the literature and designed and implemented a high-fidelity, medical simulation-based Harvard Medical School MEDscience course, which was integrated into high school science classes through collaboration between medical school and K–12 faculty. A structured telephone survey was conducted with 30 program alumni from the inaugural school who were no longer in high school. Near-term effects, enduring effects, contextual considerations, and diffusion and dissemination were queried. Students reported high incoming attitudes toward STEM education and careers, and these attitudes showed before versus after gains (P _ .05). Students in this modest sample overwhelmingly attributed elevated and enduring levels of impact on their interest and confidence in pursuing a science or healthcare-related career to the program. Additionally, 63% subsequently took additional science or health courses, 73% participated in a job or educational experience that was science related during high school, and 97% went on to college. Four of every five program graduates cited a health related college major, and 83% offered their strongest recommendation of the program to others. Further study and evaluation of simulation-based experiences that capitalize on informal, naturalistic learning and promote self-efficacy are warranted.

Students attributed high levels of impact on their interest, actions, and confidence in pursuing a science- or health care related career to the program. Students also reported positive yet moderate levels of encouragement from family, friends, and teachers. Bandura et al.'s prospective, longitudinal path analysis of 11 to 15 year olds showed that children's academic and career efficacy predicted career choices designated a year later.

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Importantly, Bandura et al. emphasized that self-efficacy influences not only preferences but also motivation, persistence, and determination to "stick it out" through challenging times in a career pathway. In contrast, academic achievement failed to add predictive value in the 2001 Bandura et al. study. Similarly, in a U.S. national sample of eighth graders, a student's expectation that she or he would have a career in science was a stronger predictor of later achieving a science or engineering degree than was their eighth grade mathematics achievement score. Specific to STEM educational choices and careers, others have shown that self-efficacy regarding research skills predicts undergraduate student aspirations for research careers and that self-efficacy beliefs enable "the perseverance and resiliency required to overcome a variety of academic and career obstacles" for women who have selected and excel at careers in mathematics, science, and technology.

Aspden, Cooper, Liu, Marowa, Rubio, Waterhouse, and Sheridan (2015), determined the level of knowledge New Zealand secondary school career advisors had regarding the pharmacy profession, how they obtained knowledge of the profession, and their potential influence on students' decisions to study pharmacy. Over 90% of career advisors were familiar with the roles of pharmacists in the community setting; however, many had a poorer understanding of other pharmacist roles. Advisors who responded to the survey were found to have varying levels of knowledge about the pharmacy profession. Several trends emerged. The first was that career advisors were most knowledgeable about basic community pharmacy roles, suggesting that career advisors are familiar with the traditional roles of a pharmacist. They were, however, less aware of pharmacists' roles in other settings. The statements career advisors answered as "incorrect" or "unsure" predominantly related to the role of a pharmacist in the hospital or industrial settings. This may reflect the perceptions of the general population regarding the activities of pharmacists. Nonetheless, the varying levels of knowledge may have limited what career advisors told students regarding a career in pharmacy and, in turn, potentially dampened interest or hindered students' understanding of the full range of career pathways open to them. Research into health careers in general indicates that providing pharmacy-specific career progression workshops in schools may increase the number of students applying to pharmacy programs and seeking pharmacy-related jobs. Career advisors can play an important role in students' career decisions and the information they provide to students can influence their potential career choices. One suggestion for improving the promotion of pharmacy within secondary schools was a greater involvement of pharmacists and pharmacy students in the promotion of pharmacy as a profession. Career advisors need a broader understanding of the potential roles of pharmacists. Increasing contact from practicing pharmacists and undergraduate pharmacy students are potential ways of increasing student interest in pharmacy.

The study indicated that almost two thirds of respondents had received requests about pharmacy as a career in the previous 5 years. Therefore, having accurate, informative resources about pharmacy courses and career paths easily accessible to career advisors is essential. Of the career advisors who received contact from universities, the most common form of contact was a prospectus. Advancements in information technology can also help school career advisors address the needs of students. Efficiently utilizing advancing technology such as credible websites and promotional videos combined with a proactive approach is considered an effective method to provide career counseling

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services to students. Of interest were the responses to the question regarding the characteristics of students to whom career advisors would recommend pharmacy as a potential career choice. The most common characteristic was personal interest and/or strength in science, especially chemistry and biology. Personal interest has been shown to be a major influence on students when deciding on a career pathway. Other common characteristics were good social and communication skills, and academic and practical traits such as being highly organized and responsible. The results were consistent with those from Kingetal's nursing study conducted in Australia, which showed that personal interest and/or strength in science, people, social and communication skills, and practical traits are among characteristics considered important to career advisors when recommending nursing as a potential career option. Participants in the study responded that increasing the promotion of pharmacy to secondary school students is likely to influence the choice to pursue pharmacy as a career. Increasing face-to-face contact with pharmacists, guest speakers, and current pharmacy students may be one way to increase pharmacy promotion to students. However, due to geographical constraints, especially for rural schools, this approach may be difficult to organize. A concerted and coordinated effort by the pharmacy profession in New Zealand might help this situation, as may improvements in communication technology. Increasing promotion of pharmacy in schools that do not actively promote pharmacy as a career would be valuable, especially for students who are not fully informed of pharmacy as a career option in the first place. Langridge et al showed that a pharmacy career explorer program increased student participant awareness of pharmacy and the roles of pharmacists and resulted in changes in opinions and attitudes towards pharmacy among many participants. Attractive and youth-targeted written and electronic materials such as brochures, videos, and posters may also help promote careers in pharmacy. Promotion specifically focusing on geographical areas and ethnicities with low pharmacy applications (eg, targeting rural areas, and Maori and Pasifika students) was another point mentioned by career advisors. Research indicates that rural areas lack access to promotional activities compared to urban areas.

Student-centered approaches taken by some career advisors in our study included referring students to pharmacists and arranging work experience, although these were used less often than activities such as one-on-one consultations and encouraging attendance at university open days. This is possibly due to challenges associated with finding available pharmacists with sufficient time to talk to interested students. Our study was not without limitations. A response rate of 45.1% means our results cannot be generalized to all secondary school career advisors throughout New Zealand. Our research findings raise some important issues, which could be further explored through qualitative studies. For example, a better understanding of how and why career advisors decide which students are appropriate for a career in pharmacy might help in more targeted promotion of the degree. Future research regarding secondary school students' perceptions of pharmacy as a profession could also be conducted. Strategies to promote pharmacy to secondary school students could then be explored and evaluated to determine which strategies are most useful for targeting students underrepresented in pharmacy schools and the pharmacy profession.

The study found that secondary school career advisors in New Zealand were familiar with the traditional roles of pharmacists in a community setting, but had limited knowledge of the roles of pharmacists in other settings. The majority of school career

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advisors believed that increasing the promotion of pharmacy as a profession would increase student interest in it. If such promotion were to be increased, career advisors' knowledge about pharmacy, its associated degree, and possible career pathways would need to be addressed, perhaps with a professional development course for career advisors specific to pharmacy. Increasing the number of visits from university liaison officers, pharmacists, and pharmacy students to schools throughout New Zealand might also raise awareness of the profession as a career choice.

Obi (2015) studied 50 undergraduate students (19-25 years old) who took part in a pre-/post-/follow-up-test to investigate the development of indecision, anxiety, uncertainty and insecurity concerning their career choice. For the assessment, the Undergraduate Career Choice Survey (UCCS) was used. The students in the intervention group (n=25) took part in six sessions of a constructionist career counselling. Theoretical background of the constructionist counselling is the "21st century career construction model" characterised by counselling as a reflective process.

The counselling followed the sequence: Constructing, collection of personal stories from the past and present of client's career; Deconstructing, seeking different perspectives on these stories; Reconstructing, re-authoring of a new story by drawing up the story into broader element of the client's life; Co-constructing, encouragement for the client to enact the new story first by presenting intentions and plans to the audience. The narrative part involves engaging in an individual's story and developing the story in order to supply: Information about career decisions; Actions which contribute to the adaption to specific circumstances.

The post-test reveals a significant decrease of indecision, anxiety, uncertainty and insecurity in the intervention group and no change in the control group (with the exception of anxiety). Highest effect sizes were calculated for anxiety and indecision. The follow-up test (8 weeks later) shows substantial and even higher reduction concerning indecision, anxiety, uncertainty and insecurity in comparison to the post-test. Constructionist interventions contribute to the major goal of career planning which are a sense of identity and meaningful vocational action. Further research is needed on the effect of shorter counselling (6 sessions are much longer than normal counselling time at school) that is less intensely aligned to an individual's needs and on the design of constructionist-based sessions to small groups.

Schütte and Köller (2015) evaluated an intervention programme designed to increase secondary school students' motivation to pursue a science career. This study is based on expectancy value theory of motivation and project-based learning. It focuses on subjective task values: attainment, intrinsic, utility value and cost. It is highly related to MultiCO interventions and may inform the design hypothesis e.g. science topics should be related to school curriculum otherwise personal value is reduced. Personal value is included in subjective task values that mediate students' achievement related choices.

In this study, students from 3 schools of the highest educational track participated for up to 2 years in the intervention programme, which was implemented as an elective in the school curriculum. Longitudinal study design for evaluating the effectiveness of the

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intervention programme included all students at the grade levels involved in the programme with students who did not participate serving as a control group. Mixed-model analyses of variance showed none of the intended effects of the intervention programme on science motivation; latent growth models corroborated these results. When the programme began, students who enrolled in the science elective (n = 92) were already substantially more motivated than their classmates (n = 228). Offering such an intervention programme as an elective did not further increase the participating students' science motivation. It seems worthwhile to carry out intervention programmes with talented students who show (comparatively) little interest in science at the outset rather than with highly motivated students who self-select into the programme.

Quite naturally, students who opted for the science elective were more interested in learning science and pursuing a career in science than were their classmates who had chosen other electives, they reported enjoying engaging in science more, they attached greater value to science, and they felt more competent. Students who are highly competent in one academic domain are likely to be highly competent in other academic domains as well. Thus, their competencies place talented students in a position where they are able to consider careers in both science and non-science fields. Familiarising these students with possible science careers might be expected to raise the odds that they will choose a science career, provided that they perceive that career as matching their interests and abilities (e.g. Super,1990; Wigfield & Eccles, Intervention to Motivate for 2000). Engaging students in activities corresponding to those carried out by professionals and giving them opportunities for hands-on activities and information about careers in science offered by the cooperating companies did not, however, increase their motivation to pursue a science-related career in the present study. To rationalise shifting their interest away from science, students may have begun to attach less value to science for themselves personally (cf. Schütte, 2015). An alternative or complementary explanation is that students may have started the programme with expectations that have not been met. The selection of the cooperating company seems critical in this regard; it may not have been a good match for some students' interests. Having to engage with a particular science topic that a student does not relate to over the course of a whole school year may be harmful, in that it reduces the personal value students attach to science; science as a domain may be tainted by unsatisfying experiences with a particular topic or subfield. With a view to a successful and fulfilling professional life, the discouraging effect the intervention seems to have had on some students might in fact be a welcome effect: Unless students are truly interested in the activities that a science career involves, they would be ill advised to pursue it.

Whether or not students eventually embark on science careers will depend on the strength of their motivation for science relative to other domains. For students to enter a science career that matches their interest, they need not be highly interested in science in general. But the pivotal measure showed no indication that students were won over for science careers by the intervention. The intervention programme employed the approach 'learning by teaching'. Principally, this approach is suitable to foster a deep and persistent understanding (Fiorella & Mayer, 2013): Students who are required to teach a scientific issue that they have recently learnt about will be more inclined to engage with it cognitively, to elaborate on it, and to contemplate different ways to address it. As a result, they spent a great deal of time in the role of a teacher rather than that of a scientist. Putting less emphasis on the teaching aspect and more on engaging in typical

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scientists' activities might increase the programme's effectiveness in motivating students to pursue science careers (Hunter, Laursen, & Seymour,2007; Seymour, Hunter, Laursen, & DeAntoni, 2004). Considerable research on science-related career aspirations has focused on under-represented groups (Ceci, Williams, & Barnett, 2009; Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013); particular barriers seem to apply to these students. However, much remains to be learnt about how to increase and maintain motivation for science careers among all students. Schools might more systematically address another aspect of students' career choices: the low visibility of many science occupations in everyday life. This may lead students to have ill-formed or false expectations of those occupations. The intervention allowed students to become thoroughly acquainted with the science occupations offered by the cooperating companies. This approach may have been too narrow, however. Science instruction might take on the task of conveying information about various science occupations.

Given the plethora of science topics and the low visibility of many science occupations in everyday life, talented but rather uninterested students may not have a good understanding of what science and science careers actually have to offer. With a view to increasing the number of students who consider pursuing a science career, the major challenge appears to be to provide all students with opportunities to engage in scientific activities that match their respective interests. In the absence of meaningful ways of engaging in science, even highly interested students may turn their back on this field. Cooperating with a regional company would seem to be an excellent way to provide first-hand experiences of the careers in science offered by the company and to establish contacts between potential future employers and employees. However, the company prescribes the range of science topics students will focus on over the course of an entire school year. Allowing students to expand the scope of scientific topics they address within the intervention programme and providing them with a broader range of information might make the intervention programme more effective.

Eyster (2007) studied college biology students and found that students had difficulties in identifying a career that uses their foundation in biology despite the variety of biology-based careers available (Eyster, 2007). The study of Eyster (2007) aimed to assist biology students and the career counselors who work with them in identifying satisfying careers that build upon their interest and foundation in biology. The categories of career options included research, healthcare, teaching, science writing, administration/management, government, industry, and miscellaneous careers that do not fit into the other categories. The first step is for biology students to become aware of the many career paths that are available and then to assess their personal interests and aptitudes in the various broad fields of biology (i.e., research, healthcare, teaching, science writing, etc.). What piques their interest? Are they more interested in plants or animals or microorganisms? How many years are they willing to devote to education? Are they willing to devote the necessary study time to achieve the required knowledge level (and accompanying grade point average)? Do they want to work outdoors or indoors? Do they want to work with lots of people? Do they want a job in a specific geographical location? Do they want a job with intellectual stimulation? Do they have other strong interests that could be combined with a foundation in biology to create a unique career? Answers to these questions will provide initial guidance in career choices. To further refine a student's interest in a particular career, an internet search will rapidly identify

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information about the length of required training, level of difficulty, job demand, projected salaries, and location of training programs for that career. Another method of career exploration is to identify people who are employed in the career of interest and ask questions, such as how did they make their career choices, what was the training pathway, and do they find the career rewarding and worthwhile. Ask whether there is opportunity to shadow the individual, or whether there are internships that would allow hands-on experience in a field to assist the decision-making process. Students should inquire about the academic rigor required for a given career choice and should critically assess their ability to meet that standard.

The way in which interests, motives, perspectives and attitudes of young people influenced the choice of study paths and careers in the STEM sector has been studied in Germany (MINT Nachwuchsbarometer, 2015). Counselling for girls in school is still affected by (gender) stereotypes. Girls are more often advised to choose jobs in social and service-oriented sectors. There are differences between the motivation to choose a STEM career related to the type of school. Pupils from the Gymnasium ('high-achieving' students) attach importance to a good earning and a good standing. Therefore, handicraft trades are not very attractive to them. Pupils from the Hauptschule ('low-achieving' students) are also interested in a good earning but likewise in practical work. There are hints that many pupils are not adequately informed about the salary in the STEM sector. Maybe more realistic information about this would make STEM careers more attractive to some youngsters.

Family and friends discourage girls from choosing a non-academic technical job five times more often than boys. This discouragement is the reason for 37,5 % of the girls for their decision not to choose such a job. Young people with an interest in STEM criticise a lack of information and especially score the counselling in school as deficient. There is a clear recommendation to organise and implement counselling early enough at school to prevent wrong perceptions about jobs in the STEM sector.

Necessary information about STEM careers is often not available or not clear enough for young people. Especially girls are often disoriented in terms of choosing a technological training. They make the decision usually after their male classmates. This may be related to the lack of female role models for identification. Moreover the better grades of girls in average enable them to make a job/training choice out of a wider spectrum. Certainly the girls do not use these many opportunities. The spectrum of the jobs that are actually chosen by girls is obviously smaller than that of boys.

Traineeships are meaningful to bridge the gap between school and the vocational world. The later chosen vocational fields are often in accordance with the earlier chosen traineeships at school. Pupils - and especially the ones with the idea to work in a STEM job - wish to get practical experiences as soon as possible. They appreciate the contact to companies in this sector and information from people in an apprenticeship. Especially boys state that personal interest and hobbies were the reason to choose a technological apprenticeship (37,4% of the female and 55,0% of the male). There is a huge diversity of organisations in the field of job counselling. However, good counselling depends on cooperation. Yet there is no overall concept that connects the school and out-of-school measures and which enables a systematic career counselling in Germany.

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The concrete decision for a study path and the vocational orientation depends more and more on extrinsic motives like high esteem. Extrinsic motives often develop in concrete decision situations while intrinsic motives rather develop in long-term socialisation processes. The career counselling has to be comprehensive and thought-out in respect to a large variety of students, some with more extrinsic and others with more intrinsic motives.

Summary of key points

The key issues regarding counselling from the literature reviewed to date are summarized here. Constructionist career counselling intervention can be used to decrease career choice indecision, anxiety, uncertainty and insecurity among college students (Obi, 2015). Secondary school students need counselling support in the areas of social values, learning skills, and vocational guidance/ development (Brouzos *et al.,* 2015). The influence of several people influence career choices. *Contacts with science professionals* (Aspden *et al.,* 2015; MINT Nachwuchsbarometer, 2015) or *knowledge about careers* (Schütte & Köller, 2015) may increase the interest to choose science careers particularly when students are interested in science and careers match their interests and abilities (Schütte & Köller, 2015). Perceptions of school science influence on career choices; if *school science* is perceived as *irrelevant* it decreases the interest to choose sciences (Cleaves, 2005). Occupational *images of working scientists,*and *stereotypical views of scientists and science* influence the career choices (Cleaves, 2005). Also the role of *family, friends and teachers* is important in encouraging in science related careers (Berk *et al.,* 2014). Career advisors need a broader understanding of the potential roles of scientists (Aspden *et al.,* 2015). Advancements in *information technology* can also help school career advisors address the needs of students. Efficiently utilizing advancing technology such as credible websites and promotional videos combined with a proactive approach is considered an effective method to provide career counseling services to students (Aspden *et al.,* 2015). These examples of studies involving counseling provide insights into the issues that can be addressed in the MultiCO project, part of the school contexts being the degree of focus there is on counseling, and what form that takes.

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2.1.5 Subject and career choice (Task 2.3, led by UCL)

Introduction and overview

This section draws on studies that have focused on the influences that determine the aspirations and intentions regarding subject choice and career plans.

A study by Bennett et al. (2013) focused on the ways in which schools with different records of uptake of science can make a difference to the reasons for uptake of physical sciences post compulsory school age. The authors identify four main strategies for choice, which include aspirational (choice based on intended career), identity (based on the type of person they want to be), tactical (keeping options open) and experiential (subject enjoyment/good teaching). The study showed differences in schools according to choice, for example high uptake school students tend to make proactive choices based on interest or career role models, whereas low uptake schools tend to have reactive choice based more on salaries or careers with challenge.

The complexity of choice is also revealed in a study by Cleaves (2005) of the formation of post16 choices over 3 years among higher achieving students with respect to enrolment in postcompulsory science courses. Transcripts from four interviews carried out over 3 years with 72 secondary school students were qualitatively analysed. Students were found to shape their choices for science in a variety of ways across time. The situation regarding science choices hinges on far more dynamic considerations than the stereotypical image of the potential advanced science student, committed to becoming a scientist from an early age. There is an interplay of self-perception with respect to science, occupational images of working scientists, relationship with significant adults and perceptions of school science. Students who chose science post-16 were students with widely differing choice trajectories, the commonest of which was the student with a 'precipitating' trajectory (Cleaves, 2005). For those who chose science from the 'directed' group, sciences were needed for a specific career ambition, and in the 'partially resolved' group there was generally an interest in particular aspects of science, which was stronger than for other curriculum subjects. By focusing on the choice trajectories of individual students, it was found that particularly students with a 'funnelling identifier' trajectory eliminated the possibility of post-16 science on these bases. Among those students with a 'partially resolved' or 'funnelling identifier' trajectory the majority of students, including those who chose post-16 science, reported a lack of relevance in the way that science was taught in school.

The issue of subject identity and choice is the focus or Holmegaard et al. (2012). Their longitudinal study of Danish students centred on those who held positive attitudes to science to see whether they went on to study science at a higher level. The authors make use of the concept 'identity work' and 'governmentality' in order to research how social practices informed the decisions students made related to further study of STEM subject. Their study concluded that what is important in career choices is not just the likelihood of getting a job, but what the job offers in terms of interest and opportunities to develop as a person and to assume responsibility for self-government. These desires are inconsistent with the experience of young people in learning science at school. A different approach in a study about attitudes and choice is adopted by Korpershoek et al., (2012) in a questionnaire study in the Netherlands comparing attitudes towards STEM

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and other subjects. The study showed the importance of significant others in influencing choices.

An overview of the theories and examples that were generated by the EU funded IRIS project (Henriksen, Dillon & Ryder, 2015) has been a useful source of further reading, some of which overlaps with key articles now discussed in more depth.

Key articles on subject choice

Aeschlimann, B., Herzog, W. & Makarova, E. (2015) report on gender-atypical vocational choice among girls. The study was conducted in the German speaking part of Switzerland to find out which factors influence career or study choices, focusing on family background and school context.
The study involved the use of the following instruments:
a) Questionnaire, > 4000 students from 42 Gymnasia and 26 vocational training schools,
b) Interviews, 87 students with a gender-atypical vocational choice,
c) Two text books (physics, chemistry) from upper secondary school were analysed focusing on gender stereotypes (in texts or pictures).

The results showed that if young women chose gender-atypical vocational jobs, the major factor seems to be the influence and support of their parents: if mother *or* father work in a gender-typical male or a gender-neutral job, or if they support girls in their maths/science skills, girls more often chose a gender-atypical vocational job. Another important factor is the school that can help by gender-sensitive maths-/science teaching and by using gender-adequate text books.

Schools also support their students' (girls and boys) choice for a STEM career by
a) counselling/informing them about STEM-jobs (and preventing stereotypes),
b) science lessons that focus on everyday contexts which are relevant to boys *and* girls,
c) science lessons that support understanding for all students (e.g. using clear language and taking enough time to explain),
d) individual scaffolding (to compensate differences in out-of school knowledge acquisition).

The study showed that the gender of the science teacher does not influence the students' career choice.

Bennett, Lubben & Hampden-Thompson (2013) present findings from a combined methods research study that compares individual and school factors that influence the uptake of chemistry and physics in post-16 A-level choices in low-uptake and high-uptake schools. Data were taken from a large-scale national data set and used to identify case studies for a more detailed analysis.

The data set was used from the National Student Database (NPD) in order to identify similar pairs of schools that had high-uptake (top 5% uptake nationally) and low-uptake of chemistry and physics A-level (post-16 choices). The schools that were paired together to be compared were grouped by characteristics such as size of school, structure

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of science curriculum (e.g. science taught separately), age range of students and % uptake of any subject at A-level.

Data were collected in three ways: through interviews with key staff (asked mainly about the strategies their school use in supporting students in making their A-level choices); interviews with groups of students (statements provided to stimulate discussion within the group); contextual data on the school (such as subject specialism of science teaching staff).

From the student group interview, results show that four main strategies for choosing A-levels were:

- Aspirational strategy e.g. choices were based on intended career or intended university course
- Identity strategy e.g. choices were based more towards the type of person they thought they were
- Tactical strategy e.g. 'keeping options open'
- Experiential strategy e.g. based on past experiences, such enjoyment of the subject or the influence of a good teacher.

The high-uptake schools tended to look towards more aspirational strategies compared to the lower-uptake schools, where students selected subjects based more on tactical grounds and past school experiences (e.g. their enjoyment and previous ability in the subject). Those students in the low-uptake school that had decided not to take chemistry or physics as an option often gave tactical ground and past experiences as reasons.

In the comparison of one pair of schools, it was noted that the high-uptake school students selected their careers according to their interest in the career or by having role models in the career. However, those in the low-uptake school based their careers on those that were the 'best' careers in terms of salaries or the most challenging. Those students in the high-uptake school in this pair of students also had confidence in their ability which was not shown in the low-uptake school (i.e. a perception that physics was 'hard').

Results for school factors showed that school management, in particular management turbulence, can have a negative impact on the uptake of chemistry and physics. Furthermore, the high-uptake schools had a broader choice of science options (e.g. double-, triple- and applied-science offers). Setting high expectations of GCSE grades to take the subject further was also shown to be an influential factor.

The nature of the careers advice in relation to subject choice emerged as crucial. Whilst all the low-uptake schools had careers advisors, they tended to give advice such as 'go for breadth' of options, which meant many students disregarded physics and chemistry as biology is often selected. Work experience and schools playing an active role in securing work placements was not apparent in most of the low-uptake schools. The most notable difference was that students in the high-uptake school were more likely to make a proactive choice (i.e. look towards their future), whilst those in the low-uptake school tended to make a reactive choice (i.e. the control is moved towards the school and decision are made on the basis of the path).

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Holmegaard, Møller Madsen and Ulriksen (2012) conducted a longitudinal study of Danish students, who held positive attitudes towards the study of science in upper secondary school, to analyse whether or not students went on to study STEM subjects at a higher level. They further studied students' perceptions of STEM subjects in Higher Education and how these linked with students' 'identity work'. Another study was also carried out of those students who went on to study STEM beyond secondary school to compare their prior expectations with the real experiences of their first year of STEM study. The aim was to understand better how perceptions of STEM subjects and students' own 'identity work' influenced future study decisions related to STEM.

Holmegaard et al. made use of narrative psychology and in particular the concepts of 'identity work' and 'governmentality' in order to research how social practices informed the decisions students made related to further study of STEM subjects. Group and individual interviews were carried out and focused on the key themes of 1) experiences of school STEM (including the relationship between students' interests and engagement and their studies) and 2) student plans for and expectations of future educational studies. A thematic approach was taken to analyse data arising.

Holmegaard et al. identified that all students in their sample, whether they chose further study in STEM or not, were motivated and fascinated by the way science enabled them to understand the world, either through awareness of the possibilities science offered or the possibilities of its application, and many explained that their interest in STEM was because it related to 'everyday life' (p11). However, there were differences reported in how students understood 'everyday life'. For some it was relevance to their personal life which was important and to others it was about the practical use of science in their everyday lives.

Holmegaard et al. found that all students recognised the methods of science and its way of thinking as special and many of the STEM choosers identified that they related to this way of thinking and were attracted to aspects of science such as its concreteness and use of rigorous and logical methods. However, Holmegaard et al. also found that other STEM choosers reported either that they enjoyed being able to solve problems autonomously and draw their own conclusions or appreciated the relationship of science to their own lives. These later two groups showed similarity to the way non STEM choosers conceived of science.

Students' views about the nature of science or their experiences of how STEM subjects were taught were found by Holmegaard et al.to influence decisions for the non STEM choosers. Perceptions of science as a fixed and non negotiable body of knowledge that needed to be 'learnt by heart' rather than understood, questioned and discussed with others and lacking a personal dimension, were common amongst this group of students. Other students reported that their motivation was adversely affected by the way STEM was taught, for example being asked to carry out experiments where the outcomes were known. Holmegaard et al. suggested that these perceptions were not consistent with the identities these students found desirable for themselves. Some students wanted to understand the use of a topic being studied and wanted teachers to offer further explanations to support their understanding. Personal relationships with the teacher were also found to be important and Holmegaard et al. reported that some students wanted teachers who 'showed involvement in the content as well as the student's' learning' (p17).

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For many of the choosers Holmegaard et al. identified that it seemed to be a significant aspect of their 'identity work' that they could connect with future job prospects, although these might be potential, as well as being located in real employment opportunities. Non choosers seemed to perceive of STEM careers in a different way to choosers and either could not see the opportunities or viewed them as isolating, with few opportunities to collaborate and interact with others or help people, and without opportunities to exert control. These characteristics were reported to make STEM careers unappealing and to contribute to the feeling that such careers would constrain students' future development and reduce their control over their careers.

From interviews with first year engineering students Holmegaard et al. identified a mismatch for many between the expectations and reality of their courses. Despite perceptions of engineering as being concerned with practical applications and problem solving, there was little opportunity to be involved in project or creative work and students mainly experienced traditional teaching methods in their first year of study. On the other hand, where first year students had received a more diverse experience, such as business visits or being involved in technological problems, Holmegaard et al. reported more interest in their studies. Holmegaard et al. suggested that students whose experiences did not match their expectations were forced to reconsider the stories about themselves and their future career hopes. Similar first year experiences were reported by mathematics students, but this was usually consistent with what they had expected.

Holmegaard et al. did not report gender differences in their findings related to expectations, although they point out that their sample was limited to those who had already chosen to study science in secondary school. However, they noted gender differences in STEM destinations, with females tending to be more likely to opt for careers related to health and humans.

Holmegaard et al. conclude that what is important in determining young adult's career choices is not just the likelihood of getting a job, but what that job offers in terms of interest and opportunities to develop as a person and to assume responsibility for self government. Holmegaard et al. assert that these desires are inconsistent with the experience of young people in learning science at school. One of the key differences found by Holmegaard et al. between one group of choosers and non choosers was not their desires about their future programme of study but their expectations about whether or not these would be provided by a course of STEM study.

Holmegaard et al. recommend that there should be a focus on two issues to increase recruitment and retention in STEM subjects, the presentation of realistic descriptions of the structure and content of STEM courses and opportunities for students to learn about issues which are relevant to the life of students, such as topics in health and environment in secondary school. They also recommend that, in addition to careful selection of content, consideration must also be given to the teaching strategies used to engage learners. Holmegaard et al. cite Johnston, 2010 to assert that young people should be able to affect the content of science courses to reflect their interests. However, they point out that some choosers make their choice for STEM subjects precisely because they like the traditional and rigid teaching methods. They therefore also recommend

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that it is important to take these learners into account when making any changes to the curriculum and teaching methods.

A paper by Korpershoek, Kuyper, Bosker and van der Werf (2012) draws data from 477 students who took advanced physics, chemistry or maths in secondary education. Of these, no student went on to STEM-related subjects in higher education. Their attitudes towards STEM-related studies were compared to their attitudes towards their current non-STEM chosen study. The data were collected via a questionnaire which also looked at the influence of significant others on the choices the students made. The data were collected as part of a large-scale longitudinal study in the Netherlands. The main results show that most students choose the 'most suitable' option. However, 1 in 10 students had a more favourable attitude towards STEM-subjects than they had for their own non-STEM chosen subject.

The approach of the study is in line with the theory of reasoned action (TRA), which is based on the assumption that people are usually quite rational and make systematic use of the information when making a decision. However, the study is also based on MAUT (multi-attribute utility theory). MAUT is based on the assumption that behaviour is linked to a person's expectations and subjective valuation of the consequences of a certain behaviour. Therefore, based on their subjective expectations, people are assumed to make choices based on the highest 'utility' score. Thus, the questionnaire compares student's utility scores on science studies with studies that they have chosen as higher education choices (e.g. law, economics, medicine), as well as technical studies.

The results show that generally, students' utility scores on their chosen studies were significantly higher than their utility scores on science studies (referred to from now as non-STEM students). However, 11% (52 students) showed a higher utility score for science studies than they did for their chosen subject (referred to as STEM candidates). Furthermore, 17% showed only small differences in their utility scores (referred to as possible STEM candidates). These STEM candidates seem to be advised to a lesser extent on their current studies, with 31% stating they were influenced by their choice compared to 39% non-STEM students. Furthermore, the results suggest that STEM candidates who were reported to have been influenced by others were more advised to choose STEM studies compared to those non-STEM students. However, despite this advice, they still went on to choose a non-STEM study. The authors do not give a clear explanation for this difference and make this explicit that they are unable to. It should also be noted that students did not indicate the expected difficulty level of science-related studies as an important factor then selecting what to study.

Wild (2015) carried out a quantitative survey of a large group of high school chemistry students in San Francisco to investigate the relationship between their perceptions of a constructivist classroom learning environment (CLE) and their expectations related to STEM careers.

The questionnaire given to students by Wild was based on the Constructivist Learning Environment Survey (Johnson and McClure, 2004) and included subscales related to personal relevance, uncertainty, critical voice and student negotiation. Wild reported that there was correlation between how chemistry students perceived of their learning

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environment and their career choices and his findings indicated that students who believed their leaning environment to be more constructivist were more likely to anticipate a science career (in particular one in physical, life and social science). However, he found that expectations related to careers in other aspects of STEM, such as engineering, computing, health and mathematics, did not show a similar correlation. He further reported that there were no gender differences, as correlations were similar for males and females. He uses 'selves theory' to speculate that the lack of gender difference may be related to perceived expectations about the extent to which males and females are represented in certain science careers, but recognises that this assumes that students have this knowledge.

Wild suggests that it will be important to understand in the future what aspects of a constructivist classroom are important when students choose science related careers, as opposed to wider STEM careers, and he cites the findings of Sha, Schunn and Bathgate (2015), who found that students make clear differences between careers which apply science, such as medicine and engineering, and those which have direct connections, to explain why perceptions of some careers are more widely linked to learning experiences than others. He further suggests that experience in the classroom in science subjects are more reflective of perceptions of careers directly related to science. Wild concludes that a constructivist learning environment may be helpful in positively influencing students' choice of a science career.

In their paper Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012) consider qualitative data from a 5 year project carried out in England looking at the relationship between science aspirations and career decisions in 10 and 11 year olds using a feminist poststructuralist theoretical perspective. The focus is on the small number of girls of this age who both identified with and aspired to science careers and looks into their identity work and how they develop and steer their way through science identities, at the same time as handling their assertions of gender identities. The study reported considered how girls visualise opportunities in the 'masculinised' field of science.
The article quote reports and research that supports the view that despite much work to increase the numbers of females in science by changing attitudes and the view of many girls that salience opportunities are open to them, this is not translating into actual choices (Ofsted,11, Darke,. Clewell and Sevo, 2002). Similarly they point to other research which notes a prevalent notion in society that maths and science are for boys. The theory underpinning the research assumes that identities which are socially constructed through discourse are ever changing and are influenced by societal features such as gender, class and race. It is acknowledged by the authors however, that even though pressures existing within society may not be in the consciousness of the population themselves, individual aspiration choices are influenced by the structures of the society inhabited. The paper also draws on the work of Butler (1990) who sees gender as performative, so that it is a result of acts executed and discussed, rather than being something which one is or possesses, as a result of an individual's gender.

The sample for this paper consisted of 17 females who were 'science –aspirant'. Unlike the similar group of boys who were from a range of classes and ethnicities, there was only one girl who was not from an upper or middle class background.

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Two main 'identity repertoires' (p. 974) emerged from the qualitative data collected: 'feminine scientist' and the 'bluestocking scientist'. Girls with both types of identities had to do much identity work to navigate the prevalent associations of science with cleverness and masculinity and a view of science that means it is not open to most females. The feminist scientist was found to do this by restraining her feminity and the bluestocking scientist through making herself asexual. Feminine scientists tended to offset identification with science by the adoption of heteronormative feminity. They mainly identified with 'being clever' and 'being into science' but were seen to be socially acceptable by themselves and their parents by developing rounded identities, displaying interests in areas such as fashion and makeup and being considered attractive, sporty and popular amongst peers. Such identities were considered to be precarious and required defending. They needed to be robust to survive science climates seen as unfavourable to woman and to avoid association with a 'geek' identity. Blue stocking scientists made up the majority of the sample. These science aspirants had less opportunity to draw on aspects considered feminine such as being attractive, fashionable or sporty and showed less interest in normal femininities. They tended to view themselves as 'non-girly' and different to their peers at school, with a strong desire to achieve academically and this was a central aspect of their identity. This identity repertoire was found to be associated with all girls from ethnic minority groups and this is closely aligned to South Asian constructs of 'good girls' as defined by Shain (2003) and to a notion of South Asian identity which arises form a perception that Asians have an aptitude for science and mathematics.

The paper concludes that having aspirations in science are particularly problematic for girls not considered clever or who are not middle class and that even those form middle class backgrounds with such aspirations must constantly seek to build an identity which allows them to be successful both as scientists and as females. The authors identify a need for opportunities to be taken in school to challenge assumptions about gender stereotyped careers and images of scientists in schools and to discuss the advantages of working in science fields for both girls and boys. They end by discussing the need for any versions of femininity conveyed by role models and mentors in science to be recognisable and to be of worth to students.

Dewitt. J and Archer.L (2015) report on two cross-sectional surveys of 9300 final year primary students and 4.600 third year secondary students as part of the 5 year longitudinal Aspires study. 1036 students completed both Y6 and Y9 questionnaires and these students' attitudes etc could be tracked over time. The students mostly came from state schools, were of a range of ethnicities and social classes, and had varying levels of cultural capital, as based on parental education, books in house, museum visitation. All geographic areas of England were covered. The study considered who is most likely to have science aspirations and the factors that affect these at two points in time. (Aspirations were considered important because without these it is thought that students would not choose science related careers). The researchers seek to identify patterns or differences between the two age groups. Attitudes to school science and parental attitudes were found to be common factors at both ages, there was also consistency in those having positive science attitudes but these did not necessarily result in science aspirations. The authors suggest this difference can be explained by differences in 'science capital'.

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Science capital is defined as:

"… a conceptual device for collating various types of economic, social and cultural capital that specifically relate to science—notably those which have the potential to generate use or exchange value for individuals or groups to support and enhance their attainment, engagement and/or participation in science " (Archer, DeWitt, & Willis, 2014, p. 5).

Dewitt and Archer refer to previous research which suggests that being positive towards science does not always convert into aspirations in science. They suggest that 'identity' or a sense of self influences the link between attitudes and aspirations. Equalities also impact on this relationship between aspirations and attitude. The study uses mixed methods of questionnaire and interview.

Students most likely to have high aspirations in science at Y9 had the following attributes: male, non white, high levels of cultural capital, relative working in science, and high attainment in science (identified by teaching set). With the exception of teaching set and information about family members, this paralleled the profile of a Y6 student most likely to have aspirations in science.

Factors most closely connected to science aspirations in Y6 were: gender, ethnicity, cultural capital, parental attitudes to science, students' attitudes to school science and self-concept in science. Factors particularly important were parental attitudes, positive self-concept and attitudes to school science. This was similar to students in Y9, although participation in science related activities was significant at this age too. Data suggested that students' positive attitudes to school science lessons declined over the time period. Parents with a positive attitude to science who actually work in science seemed to have a stronger influence on student aspirations than those who do not.

Dewitt and Archer highlight that the data again confirms that positive attitudes to science do not lead through into aspirations at both ages and the likely influence of the ability to see oneself as a scientist on career choice. They emphasise the importance of possessing science capital, which supports a vision for children that science is 'what we do' and provides tangible resources and help in achieving, in positively influencing aspirations in science.

Dewitt and Archer suggest there are a number of ways to encourage the transfer of aspirations into career choices in science, including making links between science skills and employability by illustrating careers that use skills and the provision of information specifically about careers in science. They also emphasise in their conclusions the impact of the way science and science careers are messaged at home and in schools from an early age on students' conceptions of who does science and therefore on student aspirations. In particular they identify the practice of only allowing the most able in science to pursue more vigorous science courses as a barrier to the development of positive science aspirations.

In another study involving the same authors (Dewitt, Archer & Osborne, 2013) they investigate a possible incompatibility between views and perceptions of science and scientists and students developing identities as an explanation for low interest in science

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study post 16. Previous research points to a link between ones' sense of identity and career choices. The authors suggest the limited knowledge of young people about science may restrict perceptions of career work places in science for themselves, as shown in previous research. Similarly there are previous findings that indicate that students' views of themselves are in conflict with their perceptions of scientists. Their research looked at Y6 students' ideas and their parents' visions about students who were considered likely to study science or really 'into science' and views of scientists respectively. They also analysed the underpinning concepts for these views.

Data used in the research were taken from the phase 1 qualitative dataset of the Aspires project. The dataset comprised 78 parent structured interviews and 92 children interviews from 11 primary schools across England. Within the student population studied, only 29% showed interest in a job which used science skills and 17% in becoming a scientist. The research population was varied in terms of ethnicity and social class but there were more females than males in both the student and parental cohorts.

Data analysis drew on Foucaudain conceptions of power. Patterns in the data related to respondents' gender, ethnicity and social class were also studied. Analysis showed that terms like boffin and geeky, terms frequently used to describe stereotypical scientists, were used by many parents when describing children who would go on to be scientists but this was rarer from children when describing children who were 'into science'. Many parents did recognise these as stereotypes too and were willing to challenge these assumptions. The researchers postulated though that many children are developing career aspirations in climates where scientists are linked with 'otherness' and not like 'regular' people.

The authors highlight that most parents did not adhere to the view of the 'geeky' scientist but they nevertheless considered scientists to be in some way different, even if this is considered a positive trait, to those not working in science. Their conceptions of scientists could be categorised in one of two groups: the clever scientist (clever more often seen as innate by parents) or the scientist with a particular mind set (which may include characteristics which are seen as positive such as highly focused, persevering and hard-working, logical and methodical, although also conveying that these are qualities not available to everyone). The authors suggest that the view of the clever scientist is so omnipresent that it needs to be challenged rather than ignored.

An interesting finding showed that large numbers of the children in particular held views, which were in contrast to traditional stereotypical ideas of a scientist. Being keen on science was considered an interest rather than a personality type. Some responses also indicated that scientists needed to be creative. The children's responses were also found to challenge conceptions of the scientist as socially inept, although not true for all children and there was some association with popularity and conceptions of good looking. Discourses were found to be common across ethnicities, gender and social class.

The authors were at length to stress that not all y6 students were seeing science as linked to 'otherness' and suggest that intervention at this age might lead to the development on images which do not conform to stereotypes, but it must be acknowledged that this

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age is one at which the perceptions of scientist as 'other' can also be easily established. The authors advocate early career education which introduces students to a wider range of science jobs, teachers actively working to open out constructs of the scientist and science and adopting a more inclusive approach. They conclude that these measures would help students locate science within their 'own developing identities' (p.1474).

Theories used to study subject and career choice

Social Cognitive Career Theory (SCCT), derived from Bandura's (1997) Social Cognitive Theory, highlights how cognitive-person variables such as self-efficacy and outcome expectations help to formulate an individual's agency that, acting alongside aspects of a person's environment, impacts on an individual's choice formation in relation to their career development (Lent et al., 1994). SCCT suggests career choices tend to reflect peoples' beliefs about their self-efficacy. Typically used in relation to career change and utilised by career advisors, SCCT has also been shown to be a predictor of career aspirations and choices amongst high school students (Lent et al., 2010). One such study surveyed 600 Portuguese high school students using a range of measures to rate their self-efficacy and outcome expectations as well as their interests and occupational considerations relating to 42 different occupations on 10-point Likert scales. The results suggest that career choices reflect the students' beliefs about their self-efficacy and their outcome expectations as well as supporting the assumption that career choices are made which are linked to one's interests. The correlation between self-efficacy and choice considerations concurs with other studies relating to the formation of science and physics choices in secondary education (Cleaves, 2005; Stokking, 2000).

A path model that shows the SCCT's links between self-efficacy, outcome expectation, interest and choice that represent the interest and choice models (Lent et al., 1994) for SCCT is shown in Figure 1. The path model depicts three hypotheses about SCCT: 1) self-efficacy predicts outcome expectations; 2) self-efficacy and outcome expectations jointly predict interests (SCCT interest model); and 3) self-efficacy, outcome expectations and interests predict choice considerations (SCCT choice model). SCCT also hypothesises how environmental factors, i.e. social supports and barriers, directly link to occupational considerations.

According to SCCT (Lent, Brown, & Hackett, 2002), self-efficacy beliefs are obtained and revised via "four primary types of learning experience: (1) personal performance accomplishments, (2) vicarious learning, (3) social persuasion, and (4) physiological and affective states (Bandura, 1997)" (p.262).

Lent, Brown, & Hackett (2002) highlight that:

"Outcome expectations are personal beliefs about the consequences or outcomes of performing particular behaviors. Whereas self-efficacy beliefs are concerned with one's capabilities (Can I do this?), outcome expectations involve the imagined consequences of performing given behaviors (If I do this, what will happen?)" (p.262).

External environmental support and barrier factors are also shown to impact on a person's self-efficacy and outcome expectations and therefore on career decisions. The

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relationship between self-efficacy, outcome expectations, interests, support and barrier effects and occupational considerations can be seen in Figure 1.

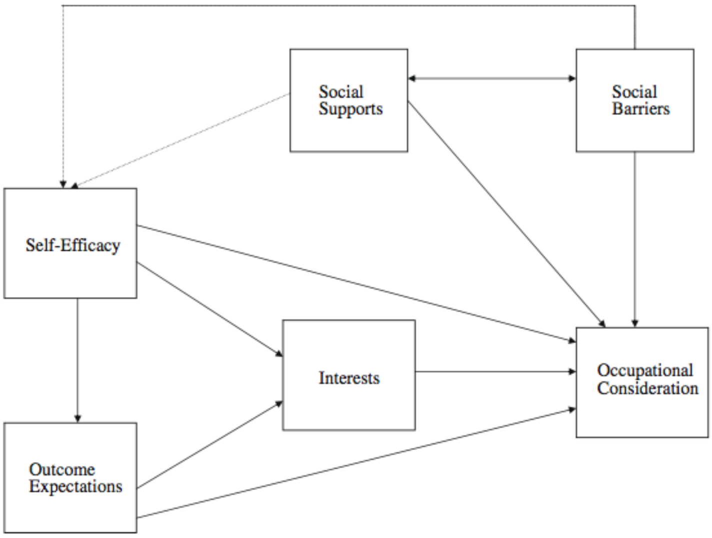

Figure 1 SCCT model

The results of the Lent et al. (2010) study show that SCCT can be used to predict the career choices (and thus subject choice to empower the opportunity to meet the requirements for the chosen careers) of high school students. They also concluded that parents had a bearing on the students' self-efficacy rather than a direct impact on the occupational considerations of the students.

A direct link between environmental factors and self-efficacy beliefs, a construct of Bandura's (1999) social cognitive theory, but interestingly not Lent et al.'s (2000) SCCT, is also shown in Figure 1. The Lent et al. (2010) study showed strong, positive correlations with the three hypotheses of SCCT. It also demonstrated that social supports and barriers do not actually directly link to choice considerations (Bandura et al., 2001), as in the SCCT, but instead, in accordance with Bandura's social cognitive theory, they have an indirect link to choice considerations via the students' self-efficacy. Thus, the overarching importance of self-efficacy on outcome expectations and in formulating interests and choices is demonstrated. The findings of the Portuguese study echo those of an earlier study conducted by Lent et al. (2003) on Italian high school students. The SCCT highlights the influence that outcome expectations (what a course of action will achieve) have on a person's interests. This relationship between outcomes expectations and interest is also present in Eccles' (1987) expectancy-value theory (Hazari et al., 2010) and thus in the expectancy-value model of achievement-related choices (Wigfield & Eccles, 2000).

Eccles' (1987) expectancy-value theory has been widely used in the field of motivational behaviour and education choice and decision-making including STEM-related educational choices (Bøe et al., 2011). The theory posits that students' achievement and achievement related choices are mediated by their expectancies for success and subjective task values. In the expectancy-value model of achievement-related choices (Wigfield & Eccles, 2000), subjective task values consist of four components: interest value, attainment value, utility value and relative cost. As in other expectancy-value theories,

the model illustrates how motivational behaviour is regulated by the outcome expectations of conducting a certain course of action (e.g. what a person expects to achieve by studying physics) and the perceived value of those outcomes (i.e. how important that achievement is). However, Bandura (1997) highlights that one's idea of their own self-efficacy and capabilities (e.g. how good they are at physics) mediates the course of action people take (i.e. choosing to study physics). Self-efficacy beliefs have been shown to contribute more to occupational (choice) considerations than outcome expectations (Wheeler, 1983). Although aspects of self-perception are implied in Wigfield and Eccles' (2000) model, explicitly linking self-efficacy with outcome expectations, as per SCCT, enhances the predictive abilities of the expectancy-value model of achievement related outcomes) and so highlights the possibility of utilising SCCT as a predictive model for subject choices. Interest in SCCT and expectancy value theory is not distinguished between individual or situational interest. As our understanding of the relevance of these theories develops, it might be a good idea to link these two theories with situational interest theory. Interest-enjoyment and utility value (components of subjective task value) are closely linked to situational interest. Based on the premise that regular experiences of situational interest in science learning can be the starting point for individual interest in science, these two factors form the main affective components linked to interest development combined with positive feelings towards an activity.

In Section 2 of the MultiCO pre-questionnaire, elements are used to measure aspects of students' self-efficacy. Self-determination theory could be mentioned here as well. According to this theory, psychological growth of an individual is manifested by intrinsic motivation or the engagement in a behaviour which the individual perceives as inherently interesting and enjoyable without being pressured from external factors. Interest has an important role in initiating an intrinsically motivated behaviour. People's intrinsic or identified motivation to engage in an activity associates with the importance of fulfilling innate psychological needs. These needs include: autonomy, competence and relatedness. (In MultiCO project we evaluate these items in pre-test and scenario evaluation questionnaire).

Section 3 is used to rate students' outcome expectations and utilizes the Harvard-Smithsonian Persistence Research in Science and Engineering PRiSE study components that was also analysed in the Hazari et al. (2010) gender study in relation to Physics IdentitySection 4 is split into two parts. The first part rates students' interests to science and STEM topics. The second part rates statements relating to environment and barriers and considers intrinsic motivations linked to physical sciences. These sections of the pre-questionnaire have a close association to the Hazari et al. (2010) gender study on physics identity which concludes that in order for a (female) student to consider Physics they have to have a 'physics identity' which is based on a synthesis of factors relating to students' "performance, perceptions of competency, perceptions of others, and interest" (p.998).

We should be able to identify links between student's self-efficacy, outcome expectations, interests, environmental supports and barriers and their career considerations (as well as potential subject choice) in accordance with the SCCT. Self-efficacy could be measured in post intervention surveys and we should consider how the interventions are adapting students' self-efficacy beliefs in relation to the associated topic of study.

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Also, we should try to identify if the interventions impact on students' perceived barriers to considering a career (in physics for example) by altering their outcome expectations as they discover more information about a career that may be unknown to them prior to the intervention.

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2.1.6 Summary of implications for MultiCO

As indicated throughout this background paper for the conceptual framework, the behaviours of main concern in MultiCO are the choices made by students at critical points that determine their career paths. The motivations, interests and attitudes that underpin behaviour can be fostered by activities designed to raise awareness and extend experience of opportunities in STEM. These can be supplemented by appropriate counselling that takes into account student factors and processes of communicating about STEM careers. The conceptual framework underpins the main instrument (pre- post questionnaire) that is used for establishing the variables to be explored in the study. This has been used to design the pre-questionnaire along these factors:

1) Student background factors

2) School factors: School type, route through school/science, modes of choosing subjects at critical ages (how choices can be facilitated, e.g. through counselling).

3) Hobbies/early years interests, that are indicators of motivation.

4) Experiences, perceptions and affective response of science learning environments – e.g. practical work, problem-solving, inquiry based approaches, everyday references.

5) Perceptions, aspirations and intentions –subject choices and career intentions.

6) Self-perception regarding subjects, including self-concept and self-efficacy.

7) Influences – who do students listen to about career choices (parents, friends, teachers, others).

8) Careers guidance/counselling - experiences and opinions of utility.

9) Awareness of different careers and also salaries and opportunities.

10) Stereotypes of science careers– how students identify themselves with these. The methodology for addressing these factors has also been woven into the instruments and methods used by each partner in the intervention phase of the project. Instruments have been developed to ascertain the value of scenarios, central to the focus on situational interest, and the teaching modules in which they are embedded. Observations and interviews are informed by the need to determine how the scenarios and teaching approaches stimulate interest (or not) – thus an essential part of the research is to explore the long-held assumptions about what interests students, and other factors that inspire their aspirations to study and take up careers in science.

As the project progresses there will be further additions to the literature review as these become available.

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Appendix 1: Analysis of the articles on activities

	STEM-related intervention	Methodology for measuring the impact of intervention	Measured impact
Dabney *et al.* (2011)	Out-of-school activities (science groups, camps, clubs, competitions, reading/ watching non-fiction science, science-fiction books/ movies	Survey among I year university students (N=6882), containing 50 questions about topics like middle school science experience, high school background information, high school science classes, science-related interest and attitudes, and career plan development. Survey data analyzed by using Logistic regression analysis.	6,4% of survey participants had participated in out-of-school activities at least a few times a year and these respondents were more likely to report a career interest in a STEM discipline. Also logistic regression analysis showed that males were 4,5 times more likely to report interest in STEM career than females. Students who reported being interested in middle school science and math had higher odds to report interest in STEM related career. Students with higher socio-economic status were more likely to report STEM-related career interest.
Archer *et al.* (2014)	6 weeks lasting intervention, combined of different activities: 2 excursions to Center of the Cell, Big Bang Fair (STEM conference), visits from 7 STEM Ambassadors (networking activity for 15-20 minutes in groups aiming to find information about their job and personality; followed up by research about the most interesting area of research), visits from researchers in residence, session presented by STEM roadshow; participation in	Pre-intervention **questionnaire** (ASPIRES): containing items of aspirations in science, attitudes to school science, (perceived) parental attitudes to science, participation in science-related out-of-school activities, self-concept in science, peer attitudes to school science and science, perceptions of scientists + open ended question for listing as many STEM jobs as students know. Post-intervention ques-	This intervention did not change significantly students' aspirations or views of science, but it had positive effect on broadening students' understanding of wide range of jobs science can lead to and be useful for (concluded from questionnaire analysis). Interview data showed more positive impact of the intervention on students' attitudes toward these kind of activities.

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	Prince's School of Traditional Arts 'Maths/Textiles Project'; 6 teacher-led sessions about perception and jobs in STEM	tionnaire had removed parental item, and participation in after school science- related activities. Pre- and post-intervention questionnaire finished by 68 year 9 students (13-14 y.o.). Voluntary group discussion/ interview (3groups of 5-6 girls) 6 months after intervention aiming to find out: overall impressions, recollection of STEM week's activities (what enjoyed and what not), whether anything was learnt (also about careers in STEM); whether students had recognized the connection with STEM careers; whether they felt change in attitudes toward STEM careers. 2 classroom lesson observations (1- focused on STEM careers; 2- focused on role of science in non-STEM career).	
Ernst & Clark, 2012	Computer science related supplemental unit for virtual schools, containing informative videos (5) (information about computer science related careers, computer game related careers were given), tutorial videos (3), developing multi-level, two dimensional computer game.	Knowledge gains with post-intervention test with 50 questions; **Likert-scale survey** to identify students' perceptions and approaches concerning technological tools, computer video generated games, technological knowledge. 28 students participated in the post-intervention test. Likert-scale survey background information was lacking. Teacher survey and feedback was also used, but	Authors concluded that this kind of supplemental unit supported students knowledge attainment about computer science; "the use of gaming as an instructional tool supports computer science competency attainment", students liked using gaming as a means for learning and obtaining learning outcomes, but were less enthusiastic about developing the game by themselves, but authors also

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		information about these was insufficient.	bring out that there were variance between students. From teacher feedback authors bring out slight change in the number of students who wanted to pursue a computer science related career.
Gebbles, Evans & Delany, 2011	Field work for surveying sand dune flora and fauna, small mammals; flora, fauna of the rocky shore; birds and invertebrate fauna of Creswell Pond. Additional information search online. Students' representative gave a presentation to pharmaceutical company about their findings and recommendations.	**Questionnaire** for both pharmaceutical company employees and students (N=60, 13-14 y. o.). Questionnaire for employees contained 10 questions and for students 9 questions, graded 1-10, growing in strength.	Both students and employees gained benefits from participating in this project. Students' views toward industry changed to become more positive. Both employees and students reported increase in knowledge about environmental issues, flora and fauna. Students were positive about insight gained from one session at the pharmaceutical company. Although this article represented gains to both employees and students about environmental topic, it did not address STEM related career interest.
Gould, Dussault & Sadler, 2007	MicroObservatory- an online telescopes as a tool for Astronomy teaching. MicroObservatory website gives students research projects, with problems and issues about physics, astrophysics, science in whole. Problems are winded around open-ended questions (7)	Analysis of 475 students' project results (students presented their project research results online, images taken by the telescopes, data and discussion). Pre- and post- test containing 21-item assessment, derived from Project STAR Astronomical Concept Inventory (originally 47 items) and added some open ended questions for measuring gains in understanding	Students who worked with the telescopes gained considerable sophistication in identifying and analyzing variables that affect the outcome of projects, compared to the students who lacked the experience of working with it. For measuring the gains in understanding Math and Science concepts they used pre- and post- test design containing 21-item assessment,

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		Math and Science concepts. Formative analysis of online comments (N=2613).	derived from Project STAR Astronomical Concept Inventory (originally 47 items) and added some open ended questions. According to the results, although lacking comparison group, using telescopes in classroom can play important role in learning about size, scale, the behavior of light, nature of scientific inquiry. They also analyzed formatively online comments (N=2613) and concluded that students were enthusiastic about the tool, periodically they got letters saying that students got inspired by the use of MicroObservatory to further their studies in Astronomy in college.
Jarvis & Pell, 2002	Visiting space centers' mission "Rendevous with Comet".	**Pre-and post-test** design for studying both attitude changes and knowledge gains. Post-tests were done immediately after, 2 months after and 5 months after, aiming to present longitudinal effect of the intervention. Both attitude and knowledge assessments were piloted among 33 students, matching main study age-group (9-10 y.o.). For studying knowledge gains about scientific content of comets and Challenger simulation, cognitive test with	As a result the authors found the following: Significant changes in knowledge about comets (363 students increased their knowledge, 168 fell back in their post-test). Results about aspirations to become a scientist: 24% of the students improved their scores on becoming a scientist after Challenger experience, named by the researchers as Challenger-inspired scientists, and this was maintained even after 4 months, but the authors point out that the aspira-

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		7 items was used (sample given).	tion had weakened, especially for girls. Girls, who were "inspired" by the experience, were also more enthusiastic about science, but the enthusiasm fell over the following months. The girls, who showed high attitudes toward becoming a scientist in both pre- and post-test, showed no difference in attitude scores. Girls who showed no improvement and attained low attitudes toward becoming a scientist and enthusiasm toward science, showed fall in enthusiasm, and attitude decline continually through the study. Relationship between aspirations to be a scientist and the social context of science: Attitude test explored children's attitude of the value of science in a social context and enthusiasm for science in general. Girls improved their social context ratings. Boys who were inspired by the experience and the ones who maintained their high attitude toward scientist career, showed risen ratings in their social context ratings. Students showed increased perception of the importance of computer science in space research; need to access telescopes in space science; students showed gains in appreciating space science as a

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			protector of our planet, but the results faded in time, but not below pre-test value. After using multiple regression analysis, authors imply that Challenger experience leaded to improvement in cognitive scores for students, who had positive attitude for space, who were self-allured and with high working confidence score and had pre-knowledge of comets. Attitudinal gains were greater for students who were already aware of social benefits of science and who appreciate teamwork and planning in fulfilling a task.
Mey *et al.* 2014	Neuroscience club as an after-school program containing activities like hands on exploration of the brain, learning its' functions and anatomy; musical instrument development, National and Mini Brain Bee competition.	**Questionnaire** for feedback about general satisfaction with the program, knowledge transferred, satisfaction with the graduate interns (were leading most of the activities), knowledge and practical relevance.	Although the project itself had interesting activities involved (competitions and invention), it lacked theoretical support and reasoning behind the activities. The amount of students was not mentioned, questions in the questionnaire was not presented. The project reports positive results, but as its' methodology is lacking, it makes one question about the reliability and validity of these results. Additionally the projects' aim was to promote science and neuroscience among students, but nothing was presented about science related ca-

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			reers or how these activities might have impacted students interests in careers related to STEM.
Muscat & Pace, 2013	Out-of-classroom visits to blood bank and greenhouse as complementing classroom learning.	Pre- and post-intervention concept map and Vee diagram analysis; pre-and post- intervention interviews, class discussions	Analysis results indicated, that none of the students (18) who participated, considered out-of-school activities as a source of information. Students considered experiments as a source of information. According to students, direct observations and visits are better than watching the same thing on film. Additionally comparison of students concept maps showed growth in knowledge, resolving misconceptions and already known concepts were extended. Although this article presented unique way to survey cognitive gains (Vee diagrams and concept maps) it did not address careers that were seen through these activities.
Orthner *et al.*, 2013	Implementing career-relevant instructions in the core curriculum in 4 subjects: mathematics, science, language arts, and social studies (in three years from grades 6-8)	Effects of CareerStart introduced in 7 middle schools were compared with 7 control group schools. School psychological engagement among 8th grade students was measured with 2 **standardized scales:** School valuing and School engagement.	Results showed that students' psychological engagement declined over the middle school years (6th to 8th grade). Students, whose teachers used career examples in teaching core curriculum, were more likely to maintain high levels of engagement and valuing of school (only school valuing was statistically significant). Additionally the

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			more teachers used career examples in core subject teaching, there were significantly higher effects on both valuing school and engagement in school. This article did not research intervention effect on students' career choices, but focused on using career examples in teaching as a way to make learning more meaningful and relevant.
Welch & Huffman, 2011	6 weeks lasting after-school robotics program, for developing a robot for special purpose.	Pre- and post-test design and control group was used. Authors used TOSRA (test of science related attitudes among secondary school students by Fraser (1981)).	Authors bring out that participation in this robotics program had positive effect on 4 categories (social implications of science; normality of scientists; attitude to scientific inquiry; adoption of scientific inquiry; but no difference was found between control group and robotics group in 3 categories (enjoyment of science lessons; leisure interest in science; career interest in science). It was concluded that participation in authentic scientific problem solving, can significantly change students attitudes and views of science into more positive, which may lead to science-related career choices in the future.
Chapin *et al.* 2015	Two food-safety workshops, which were designed as problem-based modules during 4-H camp and workshop. Students had to solve a problem of	Assessment for evaluating learning gains, perceived learning gains and participant satisfaction.	Authors implicate that students indicated increase of enthusiasm for science and food science and more than half of the students indicated their

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	"foodborne illness breakout".		aspiration to learn more about the subject covered. Students' knowledge gains were also brought out in topics covered in these modules. Although science related career interest was not directly asked, authors write that interest for food science and topics covered, interested students to study further and made them feel enthusiastic, which might have an influence on students' choice of career in the future.

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