D6.8 Final report and recommendations

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

Call: Call for Making Science Education and Careers Attractive for Young People – SEAC – 2014/15 and particularly to SEAC.1.2014.2015 - Innovative ways to make science education and scientific careers attractive to young people

Project Acronym: MultiCO

Project ID: 665100

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1. Introduction

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 have 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, 2007) 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). Unfortunately, middle grade students are not made aware of career options, and few indicate knowing professionals actively working in science, technology, engineering and mathematics fields (Maltese & Tai, 2011). Furthermore, we know that in recruiting graduates, employers indicate that the most important skills are team working, sector-specific and communication skills (European Commission, 2010).

This project built on these research results and studied the impact of:

(1) the introduction, for secondary school students (ages 13 to 15), of real life related, career-focused stories, referred to as scenarios, which initiate context- and inquiry-based science studies;

(2) increasing students’ preferences for choosing science studies and their desire to reflect on an increased awareness of, and the attractiveness in pursuing, science-related careers taking into account students’ own ideas to enhance the relevance of science studies.

The intended outcome was to motivate young people to extend science studies and orient them towards considerations of undertaking science careers. This has been undertaken through longitudinal studies involving interventions using motivational scenarios. These scenarios were created in multi-stakeholder co-operation. While a key aspect of the project was capturing the student viewpoint, research within the project heavily focused on producing evidence of the impact of a career-awareness on students’ science study choices, and attitudes towards science-related careers.

At the beginning of the project, the project (1) formulated a theoretically justified conceptual framework for the research. The project also (2) identified modern science-related research and innovation developments, scientists’ work and careers linked to developments as well as their work/career stories. Furthermore, the project (3) determined and analysed perceptions, related to scientific careers, among different stakeholders as well as students’ perceptions of careers and working life skills/21st century skills. Using the knowledge of careers, the project (4) designed a collection of student motivational, innovative scientific career-related scenarios and determined students’ views related to the value of these scenarios in promoting science education as well as providing supervisory guidelines for teachers for using scenarios in science teaching. Further, the project (5) obtained detailed, research-based evidence on students’ interests, attitudes, experiences gained and career choices. The project

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followed (6) students' science courses and career choice intentions. The project proceeded based on the following assumptions through the phases shown in Figure 1:

(a) society oriented, context-based science education, modelled to include scientific investigations, can increase students' interest in choosing science studies;
(b) focusing the context-based science education on career awareness and working life skills can raise students' interest in studying science-related careers;
(c) raising students' preferences for studying science allows students to become familiar with science-related careers;
(d) raising students' preferences for studying a more interdisciplinary and working life skills oriented science programme is relevant for students and they can be guided to acquire skills such as collaboration, creativity and reasoning.

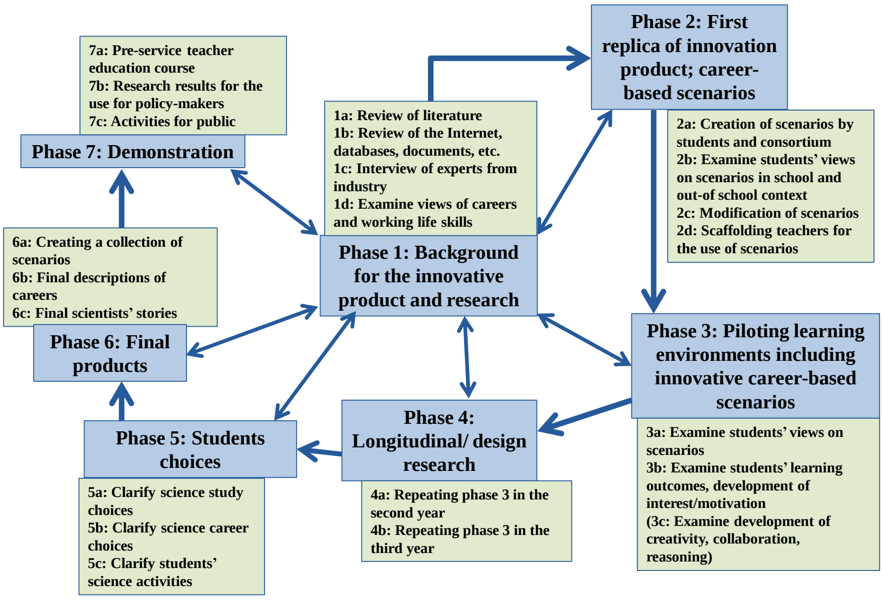

Figure 1. Overview of the Project phases

In undertaking the above, partners:

- Formulated a theoretically justified conceptual framework addressing motivation, awareness, relevance and interest issues, related to science education through an extensive meta-analysis of research-based literature.
- Determined students' and stakeholders' perceptions of working life skills in the context of interdisciplinary science teaching and science-related careers through created and piloted questionnaires and through focus group, out-of-class, discussions.
- Utilised identified research and innovation developments, scientists' stories relating their work and careers (with a particular focus on women in science-related careers), to develop motivational, career-related scenarios, further enhanced through reviews of different databases, the Internet and relevant documents, as well as from interviewing experts from industry.
- Examined students' views of these scenarios using focus group discussions in an after-school and classroom context. Modify scenarios based on findings.
- Created and piloted a preliminary collection of innovative, science-related, career awareness scenarios, which also draw attention to relevant career-related skills and lead

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to student participatory follow-up science learning through the consortium creating, together with experts from industry and civil society organisations, scientists, teachers, parents, and counsellors, career-based scenarios covering the following global integrative issues: energy, water, waste, climate change, food, health and transport.

- Solicited detailed, research-based evidence of student interests in science studies from their experiences gained. This research was accomplished through evaluating classroom practices by using questionnaires, student interviews, focus group discussions, student narratives and from direct observations. Students at school are followed for three years; with two interventions per year. Schools were encouraged to co-operate with industry during the interventions and dialogues recorded.
- Finalised selection of effective scenarios, materials on presentations of scientists and a diverse selection of modern professions which are science-related through discussions within the consortium and based on experiences and research evidence, the collection to be presented and finalised.
- Evaluated the effectiveness of the science courses provided, related to educational gains, interest in science studies and the interest in an uptake of science-related career choices through a survey focusing on students' science study or career choices following three years of study. The survey will be supplemented by interviews.
- Disseminated experiences and research outcomes through dissemination of publications on the findings, materials created in an on-line format and on-line recordings of presentations for different stakeholders, through a course provided for pre-service teachers and activities developed for the public on career awareness and the expectations for student involvement in the diversity of science-related careers.

The project was implemented via six work packages: WP1 Management; WP2 Conceptual framework; WP3 Developing and Analysing Career-based Scenarios; WP4 Intervention Studies in Secondary Schools; WP5 Students Science Study and Career Choices; WP6 Exploitation and Dissemination and the project sought responses to the following *initial research questions*:

- What factors affect student motivation, interest, relevance and attitudes towards learning and what are the impacts of using a context approach in secondary school science?
- What contemporary, or future science-related careers, exist in identified fields and what skills are needed in these careers as identified from scientists' stories?
- What perceptions of science-related careers do stakeholders hold and what perceptions of careers and working life skills needed in these careers, are held by students?
- What criteria identify best practice scenarios and the cultural differences important in establishing such scenarios?
- What are students' and the public's perceptions of the scenarios as motivators for science learning and awareness of future careers and stimuli for promoting science-related careers?
- What is the impact of science learning using career-based scenarios on students' creativity, reasoning and collaboration skills, plus other working life skills particularly for science-related careers?

The aims, approaches and outputs are shown in Table 1.

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Table 1. Specific aims, approaches and outputs

Specific aim	Approach	Output
Formulate a theoretically justified conceptual framework	Extensive meta-analysis of research-based literature at the onset of the project.	D2.1 Conceptual Framework Simon, S., Connolly, J., Drymiotou, I., Keinonen, T., Rannikmae, M. Scheersoi, A. (2018). Promoting science-related career awareness and aspirations: a conceptual framework and methodology involving multi-stakeholders. International Journal of Science Education. In review.
Identify science-related research and innovation developments and scientists' work/career stories.	Reviews of appropriate databases, the Internet, relevant documents; interviewing personnel from industry.	D2.4 Final descriptions of science-related careers and collection of scientists' stories (Stories, see www.multico-project.eu)
Determine and analyse perceptions, related to scientific careers, among different stakeholders; students' perceptions of careers and working life skills/21st century skills.	Development and analysis of validated questionnaire and/or undertaking focus group discussions.	D2.2 Report on stakeholders' perceptions on scientific careers (also in the manuscript "Promoting science-related career awareness and aspirations: a conceptual framework and methodology involving multi-stakeholders" D2.3 Report on students' perceptions on working life skills Salonen A., Hartikainen-Ahia A., Hense, J., Scheersoi, A., Keinonen, T. (2017). Secondary school students' perceptions of working life skills in science-related careers. International Journal of Science Education 39(1), 1339-1352. https://doi.org/10.1080/09500693.2017.1330575 Salonen, A., Hartikainen-Ahia, A., Keinonen, T., Direito I., Connolly, J., Scheersoi, A. & Weiser, L. (2019). Students' perceptions of working life skills in the UK, Finland and Germany. In Contributions from Science Education Research, Selected Papers from the ESERA 2017 Conference, Eds: E. McLoughlin, O. Finlayson, S. Erduran, & P. Childs. In review. In preparation: Adolescents Science Career Awareness: Whose role is to promote it? UEF.
Design a collection of student motivational, innovative scientific career-related scenarios; determine students' views related to the value of these scenarios in promoting science education; providing supervisory guidelines for teachers for using scenarios in science teaching.	Through multi-stakeholder co-operation, create scenarios related to global, integrative, science-related issues: energy, water, waste, climate change, food, health and transport. Students guided to construct their own scenarios. Focus group discussions with students on the value of scenario-led science teaching.	D3.1 Analytical report on students' perceptions on scenarios D3.2 A collection of 30 scenarios in English (Scenarios see www.multico-project.eu) Kotkas, T., Holbrook, J., & Rannikmäe, M. (2017). A theory-based instrument to evaluate motivational triggers perceived by students in stem career-related scenarios. Journal of Baltic Science Education, 16(6), 836–854. http://www.scientiasocialis.lt/jbse/?q=node/617 Kang, J., Keinonen, T., Simon, S., Rannikmäe, M., Soobard, R., & Direito, I. (2018). Scenario Evaluation with Relevance and Interest (SERI): Development and Validation of a Scenario Measurement Tool for Context-Based Learning. International Journal of Science and Mathematics Education. https://doi.org/10.1007/s10763-018-9930-y
Obtain detailed, research-based evidence on students' interests, attitudes, experiences gained and career choices familiarised so as to provide insights into the effectiveness of learning environments using science-related, career-based scenarios and the impact on students' science studies.	In-depth, longitudinal field studies using questionnaires, interviews, focus group discussions, narratives and direct classroom observations.	D4.1-4.3 Reports on interventions Salonen, A., Kärkkäinen, S., Keinonen, T. (2018). Career-related inst-ruction promoting students' career awareness and interest towards science learning. Chemistry Education Research and Practice 19(2), 474-483. Varis, K., Jäppinen, I., Kärkkäinen, S., Keinonen, T, Väyrynen, E. (2018). Promoting Participation in Society through Science Education. Sustainability, 10, 3412. https://doi.org/10.3390/su10103412 In preparation: How does the personal interest of 14-16 years olds in science change after their involvement in a 2-year career-based scenario program? UCL. How does the same scenario-based intervention generate students' interest and raise career awareness in different schools? UCL and UCY. Using STEM Careers Knowledge and Skills Awareness to Promote Interest in Physics. UCL. Science teachers as curriculum makers: engaging and reflecting on a University-led research project aimed at promoting scientific careers and awareness. UCL. D4.4 Report on practices and their implications
Evaluate students' science courses and career choice intentions as well as involvement in science-related activities outside school; undertaking a follow-up study to determine actual science options taken up.	Survey focusing on students' science study and career choices during and after three years of studies, triangulated by selected individual interviews.	D5.1 Comparative Report on Students' Interest Development D5.2 Comparative Report on students' choices Kang, J., Hense, J., Scheersoi, A., & Keinonen, T. (2018). Gender Study on the Relationships between Science Interest and Future Career Perspectives. International Journal of Science Education, DOI: 10.1080/09500693.2018.1534021. https://doi.org/10.1080/09500693.2018.1534021 In preparation: Secondary school students positioning themselves in relation to science in out-of-school, school and future career context. UEF.

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In this report, at first the main activities of the project are presented. More information is given in the project's deliverables (www.multico-project.eu) and articles. Finally, based on the project's studies, recommendations are given.

2. Conceptual framework

There is a substantial amount of research that has focused on the reasons for subject and career choice, which are related to the motivation, interest and attitudes, the pedagogical approaches and the available advice and awareness regarding careers. By undertaking a literature review the project aimed 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 has been achieved initially by extensive meta-analysis of the literature; the analysis established 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 interrelated 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 the 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.

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

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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 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 con-texts, 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 Synthesis and implications for interventions: motivation, interest and attitudes

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 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 and 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 and 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 and Hasni (2014) conclude from an extensive literature review that 'hands-on' activities, which do not require much re-flection, do not have positive effects on students' interest, motivation and attitudes whereas 'inquiry-based' or 'problem-based' interventions seem to have positive effects.

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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 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 pro-grams 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 and 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 them-selves as good achievers. Hence, it is important to develop students' feelings of self-efficacy in science and technology courses.

2.2 Synthesis and implications for interventions: activities for promoting STEM careers

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,

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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 (6th-8th 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., 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 to-ward 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

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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.

2.3 Synthesis and implications for interventions: counselling for STEM careers

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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2.4 Synthesis and implications for interventions: 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 out-come 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 2. 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 per-son's self-efficacy and outcome expectations and therefore on career decisions. The relationship between self-efficacy, outcome expectations, interests, support and barrier effects and occupational considerations can be seen in Figure 2.

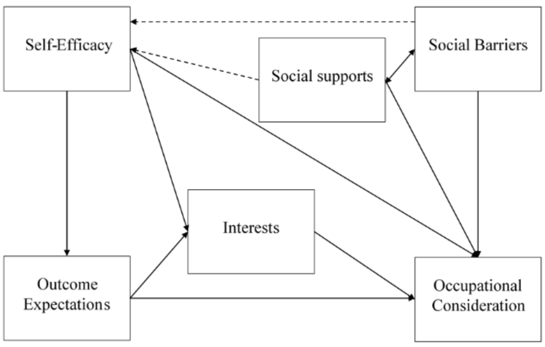

Figure 2. SCCT model (Lent et al., 2010)

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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 2. The Lent et al. (2010) study showed strong, positive correlations with the three hypotheses of SCCT. It also demonstrated that social sup-ports 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 expecta-tions 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.

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2.5 Summary

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 evaluated 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 Identity. Section 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. 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.

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 sub-jects 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.

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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.

The conceptual framework was used in creating the pre questionnaire where students' interest before interventions were mapped out (see chapter 6). In comparison to the other countries, the Cyprian students showed the highest interest in science and the Finnish students showed the lowest interest in science. The students' interest from the other participating countries ranges in between the above mentioned two countries. Noteworthy features are the combination of medium interest in science subjects and high interest in science topics in Germany. The students from the UK show a vice versa interest distribution with medium values in science topics but relatively high mean value for science subjects. In the international comparison, the most interesting subjects are biology (m= 2.85), followed by chemistry (m= 2.82), physics (m= 2.58) and geography (m= 2.57). From the science topics, the comparison reveals highest interest in health topics (m= 2.84), followed by ecology (m= 2.71), and energy (m= 2.60).

3. Working life skills

Working life skills are linked with the research questions:

What contemporary, or future science-related careers, exist in identified fields and what skills are needed in these careers as identified from scientists' stories?

What perceptions of science-related careers do stakeholders hold and what perceptions of careers and working life skills needed in these careers, are held by students?

Some examples of contemporary and future science-related careers are presented in the project website (www.multico-project.eu). Skills identified in the selected career stories are presented in the manuscript "Promoting science-related career awareness and aspirations: a conceptual framework and methodology involving multi-stakeholders".

3.1 Stakeholders' perceptions

The MultiCO project involves a multi-stakeholder co-operation between different stakeholders including researchers, experts from industry, teachers and parents, policy makers and

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counsellors. In developing the protocol/questionnaire for focus group discussions to examine stakeholders' views, items from available instruments that have been reported in the research literature (Venville et al., 2013; Glynn et al., 2011; Bøe et al., 2015) were modified. However, the consortium adjusted the format of the questionnaire in each country according to the school and the stakeholder group. Therefore, interviews, either focus group interviews or individual interviews or questionnaires, depending on the schedule of the stakeholders, were conducted in each partner country (see more D2.2). The number of participants is shown in Table 2.

Table 2. Stakeholders

Teachers	Parents	Industry experts /scientists/NGOs	Students	Research teams	Career guidance/Policy makers
27	10	17	2	12	7

Stakeholders' views of science-related careers with regards to knowledge and skills required are presented in Table 3.

Table 3. Knowledge and skills identified by the stakeholders

Knowledge required	The basis of science-related careers is mathematics. Knowledge in physics though is equally important. For example in engineering a combination of knowledge in physics and mathe-matics is required. Then biology and chemistry are fundamental to several science-related professions such as chemical engineer and environmental engineer. Specialist knowledge, general knowledge, knowledge of where scientists sit in society is also needed.
Research skills/tools for working	Qualitative, quantitative analysis Dexterity, extrapolating information Data analysis, being methodical Numeracy/maths skills, computer skills Ability to use specialist equipment Logical thinking, evaluative and higher order thinking skills, problem solving
Personal skills/ways of thinking	Creativity, Organisational, Curiosity, Will power, Self-confidence Perseverance to complete dull/repetitive tasks, Imagination, Passion, Humility, Empathy, Patience, Ambition, Open-mindedness, Analytical, Thorough, Unbiased, Adaptable, Approachable, Responsible, Concise, Written skills, Life-management Media literacy, Decision-making, Ability to draw conclusions
Social skills/ways of working	Collaboration, Team working Communication Presentation skills and public speaking Persuasive – presentation and argument Articulate Public relations/marketing Flexibility

Stakeholders perceived that girls often choose careers which they believe are family-friendly or with a reference to environment and society. If girls choose academic careers in science/the technical sector they tend to choose medicine, veterinary medicine, psychology or study programs like environmental technology, spatial planning and environment protection.

> "Science becomes interesting for young people when it is placed in the context of society and the human body (especially interesting for girls) or when the research aspect and the adventure is stressed (especially interesting for boys)." UBO stakeholder

Stakeholder expressed that there is a lack of career awareness and information on where science could lead. They perceived that students have little knowledge on the possible career choices

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especially about science-related professions. Science taught in schools is not usually related to working life.

According to the literature, the lack of real world experiences in learning science at school will have a negative impact on students ‘identity work’ and ‘governmentality’, which will compromise the likelihood of choosing a science-related career in the future (Holmegaard, Madsen, & Ulriksen, 2012). The knowledge is mostly gained from their experiences i.e. their family environment (e.g. parents working in science-related professions), and careers at hot topics (e.g. nanotechnology, robotics). These findings align with what have been reported by other studies in subject and career choice, namely the importance of significant other in influencing choices (Korpershoek, Kuyper, Bosker, & vad der Werf, 2012).

Stakeholders expressed that students possess a perception that science is a very demanding and difficult subject. However, students choose mathematics and physics because careers related to these sciences are considered as being in demand. They also perceived that students might think that choosing science subjects would be the best option to avoid unemployment.

> “Students could be interested in choosing science related career because they associate those with high incomes and good opportunities to find a job”. UT stakeholder

Politicians perceive that students are not interested in scientific careers and interest is still decreasing. Industry representatives are more optimistic and believe that some students are interested in the scientific field, and that interest is increasing. They perceive that nowadays promoting students’ interest is challenging. Scientists perceive that there are still students who are interested in sciences.

Stakeholders discussed that older students are more interested in science-related careers compared to younger students. Students perceive, according to stakeholders, that science subjects are difficult, especially mathematics and physics for girls and therefore they cannot see the advantages of science-related careers in their future life. Another reason why students are not interested in science-related careers is that science-related careers are not popular in society. Further, stakeholders perceived that the link between school science and students’ own lives is not clear for students’ and therefore they do not relate their future profession with science. Some stakeholders added that students are not aware of professions which are science-related. Stakeholders don’t have a common position; some focus on greater employment, bigger salaries and other incomes, the possibility to travel, to do research, to be creative and to demonstrate general capability in the profession. However, other stakeholders added that it is not possible to bring out general features of science-related careers that make them worth pursuing (or not worth pursuing), because it all depends on students’ personal interests and choices.

> “This depends on the access/attainment/aspiration the students has, the amount of culture/social capital, options left open" (...) This affects the perception/mindset of science careers.” UCL stakeholder

The stakeholders’ views of students' career choices and interest in pursuing science-related careers are similar to the findings reported by the literature. The reasons for the decline in students’ motivation for science 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

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in relation to grades and careers, and perceptions of school science as difficult, decontextualized and irrelevant to students' everyday lives (Lyons, 2006).

To examine possible factors that could influence (either impede or enhance) students in pursuing science-related careers, the stakeholders were asked what features of science careers made them worth pursuing and therefore of interest to students. One focus was on job prospects and financial reward. Personal reasons included variety, enjoyment, excitement and self-fulfilment leading to a sense of pride in achievement. More social reasons included that science careers were useful, and potentially helped society. Alternatively some views on what made scientific careers not worth pursing were possible feelings of isolation. There was also a perception that science careers could be boring or repetitive and also that they could lack financial remuneration and could take a long time in formal education to qualify/get experience. The following lists some key influences/factors:

- motivation (intrinsic motivation to study science/technology, excitement about discoveries/innovations, motivation to do research/lab work, interests, talent)
- science-related activities organized by the family and out of school experiences
- school-related factors (difficulty of science-related subjects, students' performance in science, science teacher)
- excitement about discoveries/innovations

The performance in science class is related to the experience of self-efficacy that is very important for the choice of a scientific career. If the pupils are confident enough in learning and doing science in school the probability of choosing a career in this field is higher. These perceptions are supported by empirical studies (e.g. Archer, DeWitt, & Dillon, 2014; Barmby, 2008). However, some stakeholders perceived this to be of less importance.

Less conclusive influences (participants differed greatly):

- financial prospects (more highly rated in Cyprus and Estonia)
- employment opportunities (more important in Cyprus and Estonia)
- contribution to scientific research
- socio-economic background
- difficulty level of science-related subjects
- students' gender

Interestingly family influences were highly rated in the UK and Cyprus, but less important in Germany. Family-related factors (pressure, socio-economic background, science-related activities organized by the family) were also highly rated in Finland.

Across the partnership there were many suggestions made by stakeholders for ways in which the education system/learning community could contribute to problem solving regarding the lack of students' interest about science and science-related careers (information about career pathways, work experience etc.):

- Show the relevance and use of science and technology.
- Parents should be more involved.
- To make scientific and technical careers more interesting and appealing for young people they should be placed in the context of society or the human body.
- School subjects are often too far away from careers in science or the technical field – they should be more connected to careers and should show their wide range.

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- Use of role models which can come into schools and talk about their daily work in science or in the field of technology.
- Negative images of scientific and technical careers have to be overcome by more adequate information.
- A wide variety of careers should be presented to allow all different types of personalities to establish an individual connection to the field.
- Schools should give young people the chance to try out and participate in science/technology to be able to align their "selfs" with possible career options
- Give young people positive feedback – "You are able to do science, you are suitable for those careers, look how interesting career in science and technology are, have a look inside these fields, have a try, you are welcome".
- Short digital course units that are target group oriented and activity-oriented (e.g. a short quiz) can be recommended to deliver short career information.
- Use attractive terms, such as "team player" instead of "teamwork" because young people have positive associations with this (from the field of sport for example).
- Schools should provide work experience and direct contact with people working in a particular industry. Better access to more current technologies and IT resources was also seen as useful, for example an engineering club. Some thought that having a day in the life of a scientists would be good: a group of students could spend the day carrying out a range of different job tasks in particular science careers, for example, examining 'blood' or 'tissue' samples for a clinic.
- The idea of scientists in industry coming to school to talk about their chosen careers/experiences was seen as useful by many stakeholders, also talks from university students, and successful professionals from different science backgrounds sharing their experience with students in school.
- Projects on STEM topics to develop knowledge and experience, with careers fairs, visits to industry/university also featured. Projects that create really useful/exciting things could be very motivating, exposing kids to real scientific challenges .e.g. building a robot for competitions.
- Introduce industry visits in science class and promote school collaboration with industries (projects).
- Build science museums that trigger students' interest and arrange school visits.
- Science class compulsory for all grades in secondary schools.
- Need to reform the science curriculum
    - employ practical work in lessons
    - teach the evolution of science in order to develop high thinking skills and understand the nature of science (e.g. a study in Cyprus indicate that students who were taught the evolution of a scientific phenomenon scored better learning results)
    - provide links with working life; that way promoting science-related career awareness.
- Implement an interdisciplinary teaching approach of STEM subjects as to prompt students making connections between science, technology, engineering and mathematics. Fostering collaboration amongst science teachers would facilitate this process.
- Promote training programs for science teachers.
- Promote the development of inquiry skills in science-related classes.
- School counsellors should provide guidance and information on the possible career choices in science while pursuing a science field (i.e. if a student chooses to study physics at the university the school counsellor should be able to provide information on job prospects/opportunities).

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- School could promote students' willingness to seek purposely in the scientific and technological fields in several ways.

Activities that stakeholders pointed out are:

- tell more and in a better way about practical applications and scientific skills
- linking instruction to practical problem-solving, environmental issues, climate change
- presenting different fields and careers, current technology and its future development
- group working, games, experiences, through inquiries, using everyday issues
- LUMA clubs
- study visits (to industry and research organisations) and expert visits (to school), co-operation between schools and universities, benefitting alums of own school, TET period (students work in outside the schools), counselling.

Many of these suggestions include collaborative work, inquiry-based learning and activities where learning science can be linked to real-life problems, and contact with role models. These aspects have shown positive links to students' motivation, interest and attitudes towards science (Potvin & Hasni, 2014).

Across the partnership we were able to draw on the views of a range of stakeholders, though it was disappointing that so few parents were able to attend meetings. Feedback on outcomes of using scenarios could provide a stimulus for parental involvement if schools are able to engage parents more fully in the project. Where industry partners have been able to be involved their insights have been interesting and in some cases show a contrast to the views of teachers and parents. Their ongoing engagement in the project can provide invaluable sources for developing scenarios that stimulate students' interest and career awareness.

In identifying stakeholders' views of science-related careers there was a remarkable degree of overlap between partner countries, but with some exceptions. Many stakeholders identified careers traditionally well-known for science such as medicine, however some stakeholders mentioned more environmental careers, different kinds of engineering and 'future' careers. Some stakeholders also identified many other careers such as plumbing, brewing, farming, where there are science-related aspects. There was a view that all careers could be related to science, but this idea was not shared by all stakeholders. Further analysis could identify trends in how different stakeholders perceive science-related careers. In identifying the knowledge and skills needed in science-related careers there was again a similarity across the partnership, resulting in a long list of skills that include the professional, personal and social skills.

Stakeholders' views of students' choices and interest did show differences between partner countries. Though there were common views such as a lack of career awareness, a perception that science is difficult and there is a lack of interest, these views were not uniform and require further analysis, particularly the contrasting idea that choice could be more related to either opportunities afforded by careers such as salary, or students' personal interests.

The questionnaire evoked a range of possible factors that could influence students' choices, and here some differences between stakeholders emerged. Family influences were highly rated in the UK and Finland, and given the relatively low involvement of parents in the project this finding should provide an indicator of how to understand choice more deeply. In contrast, in Cyprus and Estonia economic influences were more prominent in stakeholders' views regarding choice, these were less highly rated in Germany. Finally, suggestions about ways in which students' could become more aware of and interested in science-related careers were wide-ranging and could be a useful source for action when more detailed analysis of stakeholder and student data emerges as the project progresses.

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3.2 Students' perceptions

In small groups (3-4 students), the students had to work on two different science careers where different skills are needed (Table 4). These careers (altogether 12) were chosen from a list (see www.multico-projct.eu) that had been developed earlier.

Table 4: Careers used in the students' workshops on working life skills

Group 1	Chemist	Air traffic controller
Group 2	Pharmacist	Software designer
Group 3	Pathologist	Production designer (food industry)
Group 4	Meteorologist	Nurse
Group 5	Geneticist	Horticulturalist
Group 6	Zoologist	Mechatronics mechanic

Students were asked first to discuss what kind of knowledge/working life skills these careers require and write them down. Out of this list they then had to choose the three most important skills and explain in what kind of tasks and situations these are needed. Student workshops were conducted in all the partner countries with a total number of 724 students.

Data analysis was undertaken using a table with different skills and categories based on the ones that have been proposed by Binkley et al. (2012). The results from merged partners' data are presented in this report with two exemplary careers – one career "in science" (chemist) and one career "with science" (nurse). A bar chart is used to visualize the differences of the two careers in relation to the four categories (= Ways of thinking, Ways of working, Tools for working, Living in the world) and their subcategories (Figure 3). The most important skills per career that the students' have chosen are listed in individual mind maps (Figure 4).

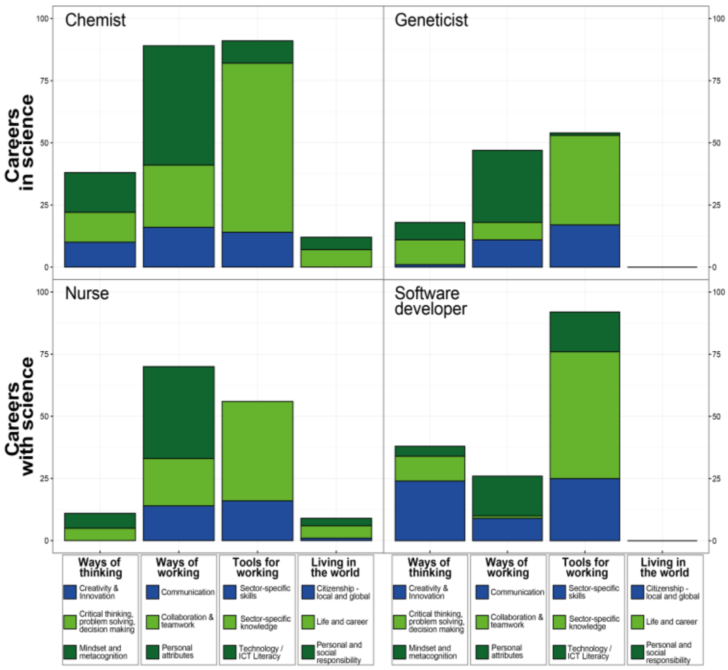

Figure 3. Comparison between the number of skills (most important skills) mentioned per career and category.

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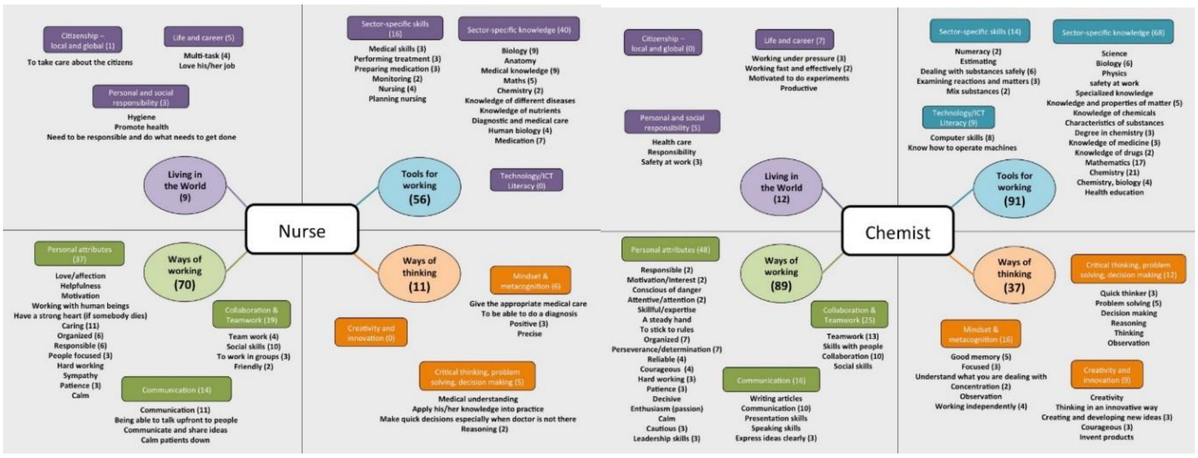

Figure 4. Chemist and nurse, mind maps with most important skills

In the Finnish case (Salonen, A. et al., 2017; http://dx.doi.org/10.1080/09500693.2017.1330575), careers that aroused the highest association with sector-specific knowledge were mostly ‘careers in science’: the meteorologist and geneticist receiving 27 references, the zoologist 24, and the chemist and pathologist 21. Students also most frequently chose these skills as being the most important in ‘careers in science’. As assumed from the students’ responses, with the exception of the meteorologist, only a few technology and ICT literacy skills were considered to be necessary in ‘careers in science’. Students generally pointed out that personal attributes play a large part in working life skills; ‘careers in science’ demanding at least three different personal attributes. ‘Careers in science’ were characterised more by personal attributes than ‘careers with science’; moreover, positive attitudes and interests related to both one’s own profession and science, were considered necessary to succeed in ‘careers in science’, especially in the careers of a chemist and zoologist. Students equally associated communication skills with ‘careers with science’ and ‘careers in science’, but collaboration and teamwork were slightly more connected to ‘careers with science’. At least one problem-solving skill was linked with every career, except for that of the pharmacist. Students pointed out that a chemist needs the most complex higher order thinking skills. From the data analysed, Living in the world skills were not regarded as generally being important and these skills were linked more with ‘careers in science’. The comparison of three countries, Finland, Germany, and the U.K revealed that (Salonen, A., et al, 2018). Summing up, secondary school students (age 13-14) have a great deal of knowledge about working life skills but it is often stereotypical. Students often pointed out sector-specific knowledge and personal attributes however skills related to career development, organisation, time and society skills were not mentioned. Some variation exists between the countries. The British students connected careers in science with a great deal of thinking skills, whereas the Finnish students pointed out sector-specific knowledge. The German students described the careers more with personal attributes than in the other two countries. We concluded that the students need learning experiences including presentation of working life skills such as interacting with professionals and their real work life problems, open-ended inquiries, and team working. These experiences increase students’ awareness and perceived relevance of careers and working life skills, help identifying and promoting own strengths and self-efficacy, and encourage choosing science-related careers.

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3.3 Career stories

Scenarios present the careers in many different ways. Introducing students with authentic career information promotes the student's career awareness, prevents and corrects stereotypes. Wide-ranging lists of science-related careers with their descriptions and / or stories help teachers to use the corresponding career related to the current curriculum-related issues.

At the beginning of the project, current and future science-related careers were searched and career descriptions created. The list and descriptions have been completed during the five interventions when using new career-based scenarios. Descriptions and stories are compiled with the idea that they should include information about the skills, knowledge and responsibilities the certain career has. In addition, stories include information about the person's background, career development, current work and possibly some information about their hobbies.

Lists of careers

The created listings mainly base on Internet and newspaper information and presented according to the field of the science. Figure 1 illustrates some of the careers. There is great number of technology careers that are somehow science-related careers but not strictly related with particular field of science.

The lists of careers include also a review of the future careers collected from different online sources. These future careers deal with the future global socio-scientific issues. Examples of such careers are Climate change reversal specialist, Simplicity Expert, 'New science' ethicist and Memory augmentation surgeon. List of found future careers with their descriptions are published in the project's website.

Descriptions of careers

The descriptions of careers are formulated based on the Internet and newspaper information; on stakeholders' focus group discussions and interviews and scenarios created during the MultiCO interventions. The career descriptions are listed in a way to be easily used as learning material such as career description cards (Table 5, some examples) and career circle (Figure 5). Career descriptions cards can be used as single items to give information about certain career or as a pairing game. The students can receive careers related to corresponding curriculum issue and then connect them with the descriptions or vice versa.

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Table 5. Career description cards

Careers	Descriptions
Paramedic	Health care professional responsible for providing medical assistance to patients while they are en route to the hospitals. They are always the first one at the scene of the accident and are responsible for the initial assessment of a patient's condition.
Astrophysicist	Explore physical properties of celestial objects, including stars, planets and galaxies. Thus, they need a substantial amount of scientific knowledge. Becoming as one requires training and skill in a combination of astronomy and physics.
Physiologist	Aims to understand the mechanisms of living; how living things work. Studies how our cells, muscles and organs work together, how they interact. They look at living mechanisms, from the molecular basis of cell function to the whole integrated behaviour of the entire body.
Microbiologist	Undertake laboratory analysis and monitoring of microbial cultures, samples and new drugs using specialist computer software and a range of identification methods and clinical trials.

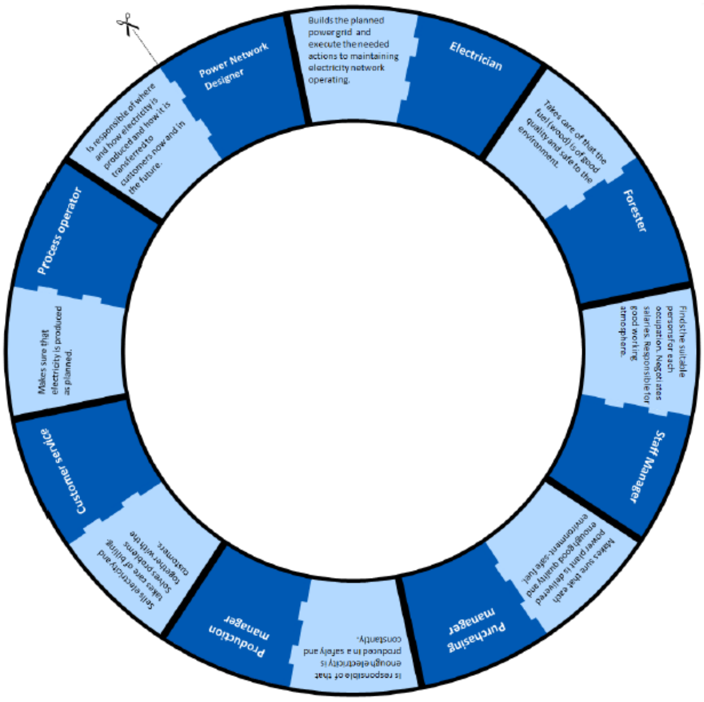

Figure 5. Career circle of the careers involved in electricity distribution

Career stories

Career stories have been structured based on the interview protocol for stakeholders and main information is clearly indicated for teachers and students to use. These career stories are of 13 female and 17 male professionals. The short versions of career introduction are easier for

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teachers and students to proceed quicker into the career and relevant problem in teaching. This kind of career cards are intended to be used for emphasizing the responsibilities, skills and knowledge required in the careers so that the students' could link these for an actual career instead of teacher just dealing with them as self-evident part of teaching.

Full career stories are aimed for students to read through, empathize and identify their selves with the career development, skills, knowledge and responsibilities. Such narrative teaching material emphasize students' connection with the career and feeling of relevance more than just listing such elements. The full career story can be found in website. The overview of career stories is shown in Table 6.

Table 6. Overview of the career stories (see more www.multico-project.eu)

No	Career in the story	Curriculum topic related to the career	Stakeholder context	Scenario including the story
1	Biologist, program manager (female)	*Biology*: diversity of organisms as a resource; organisms and habitats; agriculture: pests, fertilisers, herbicides & pesticides (future challenges: food, climate change, health, biodiversity)	Gene bank, crop varieties	Apple Diversity
2	Agricultural engineer, CEO and owner of ADDCON (male)	*Biology*: enzymes *Chemistry*: thawing salt and its influence on soil and plants, alternative products; chemistry: food additives (leaving agents: ammonium bicarbonate; preservatives: calcium propionate, KTP; improver: enzymes)	Industry, green chemistry	Road salt
3	Horticulturalist (Trainee in his last year) (male)	*Biology*: plant diversity; plants and habitats; ecosystems; plant cultivation / horticulture; role of botanic gardens (e.g. plant conservation; research)	Plant diversity, conservation	
4	Botanist/PhD student at the University of Bonn (male)	*Biology*: evolution, biodiversity, biogeography *Geography*: biogeography	Biodiversity, evolution, biogeography, botany	
5	Veterinary surgeon (female)	*Biology*: animals, animal anatomy, animal wellbeing	Veterinary medicine	
6	Transport engineer (male)	*Geography*: transportation	Transport	
7	Principle sustainability advisor (female)	*Geography*: climate change *Chemistry*: food and energy	Food and energy systems, sustainable development strategies, climate change	
8	Research scientist (female)	*Biology*: genes	Genetics	
9	Inorganic scientist (female)	*Chemistry*: water purification, insoluble and soluble	Water purification	

Both short and full career stories are published as single files in the website together with an overview table including curriculum links. Written permissions from interviewed employees and employers have been asked for publishing the stories, for both text and images.

Summing up, in the Internet, there exists a huge amount of different science-related career presentations. Companies and educational institutions offer presentations to attract young people to study science and technology fields as well as employees for the companies. These presentations, mainly in the video format, are high quality presentations. In many cases, they however, are quite difficult to use as a part of instruction in the secondary school level, they are too long, the language is not appropriate, and they do not focus on the particular and relevant school science context. The career descriptions and stories created in MultiCO project are particularly focused on the secondary school level. They present those skills and knowledge, which are seen essential to introduce to the school students. The stories constructed and based on stakeholder interviews include relevant scientific careers, skills and knowledge for the

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school science. They are from wide range of contexts related with science curriculum and main school science subjects. Even though many of the careers introduce curriculum-related contexts from the field of biology, these careers in overall represents well the whole spectrum of science fields. Moreover, most of the careers deal with cross-disciplinary topics. These stories can help students to see that, for example, the field of physics and chemistry include other, more versatile, careers than physicist and chemist. In addition, almost half of the career stories are of female scientists, which emphasizes the role of women in science. The structure and language is appropriate for science studies in this level. We also show to the teachers in which context the stories can be used and in which scenario in our website the story can be used.

4. Students' perceptions on scenarios

The knowledge about science-related careers and working life skills acquired through examination of stakeholders' and students' views of science-related careers and related working life skills as well as through interviews and information search from different sources, has been used in creation of career-based scenarios. Conceptual framework guided the creation and implementation of scenarios to find out answers to the research questions:

What are students' and the public's perceptions of the scenarios as motivators for science learning and awareness of future careers and stimuli for promoting science-related careers?

What criteria identify best practice scenarios and the cultural differences important in establishing such scenarios?

4.1 Initial scenarios

Parameters to be considered in developing the initial scenarios were (See D3.2):
1) The scenario needs to include career parameter(s)

This probably derives from industries related to science areas, which form the challenge: e.g. energy, water, waste, climate change, food, health, transportation.

2) The scenario is interesting for students (this is intended to mean interesting to students in general and hence the scenario is not gender specific).

With this in mind, the orientation can be towards an attractive problem or issue, or an unexpected or extraordinary situation, with the possibility to involve students in an unusual scientific, hands-on activity.

3) The scenario needs to be 'relevant in the eyes of the students' (not as perceived by the teacher).

The scenario context is thus most likely connected:

- to students' personal life, either now or in the future (personal relevance);
- with a social problem/issue or problems/issues, which may have a (hidden)
- science component (social relevance); and/or connected with updated global or local problems/issues (media relevance).

4) The scenario is expected to be an initiator, leading to learning that is related to the intended science curriculum, both in terms of subject matter and general (cross- curricular) competences.

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The introductory scenario is expected to provide the rationale for gaining new knowledge and competences, as outlined in the curriculum, and thus needs to be anticipated as having a positive impact on students' becoming intrinsically motivated.

The initial collection of 27 scenarios was created, four scenarios in each country (Table 7).

4.2 Evaluation of initial scenarios

The scenarios evaluated by students in intervention classes and number of evaluations is shown in Table 7.

Table 7. Initial scenario evaluation

					Total				
No	**Scenario name**	**Country (University)**	**Created by stakeholders or students**	**UT**	**UEF**	**UBO**	**UCL**	**UCY**	
0	(*Name not written*)	Finland (UEF)	No information	0	1	0	0	0	**1**
1	Eco scientist	Cyprus (UCY)	Students	7	2	8	21	0	**38**
2	City congestion leads to traffic light rethink	United Kingdom (UCL)	University	6	2	0	0	0	**8**
3	Earthquake red alert*	Cyprus (UCY)	University	6	4	3	21	6	**40**
4	Electricity in the air	Estonia (UT)	University	4	8	2	15	11	**40**
5	Interior police	Finland (UEF)	Students	11	6	0	0	0	**17**
6	Animal geologist	Finland (UEF)	Students	7	5	6	0	0	**18**
7	Apple	Germany (UBO)	University	6	7	4	30	0	**47**
8	Mysterious animal	Finland (UEF)	University	6	4	8	0	0	**18**
9	Lemonade scenario	Estonia (UT)	University	6	7	2	0	12	**27**
10	Recycling	Cyprus (UCY)	University	6	3	3	25	0	**37**
11	Chemist	Finland (UEF)	University	7	6	8	10	0	**31**
12	Dental lab	Germany (UBO)	Students	8	6	2	0	0	**16**
13	Nutritionist	United Kingdom (UCL)	Students	6	11	3	11	0	**31**
14	Dangerous substance	Finland (UEF)	Students	16	2	0	0	0	**18**
15	Sports physician	Finland (UEF)	Students	9	7	4	0	0	**20**
16	Food industry (cucumber)	Estonia (UT)	Students	6	6	8	17	0	**37**
17	Pharmacology	Estonia (UT)	Students	6	0	4	25	0	**35**
18	Thermal expansion	Finland (UEF)	University	6	8	4	0	0	**18**
19	Careers in Science: Transport	United Kingdom (UCL)	Students	6	7	5	0	0	**18**
20	GEMs	United Kingdom (UCL)	University	12	2	2	23	0	**39**
21	Sustainable	United Kingdom (UCL)	University	6	6	8	0	0	**20**
22	Solar power	Cyprus (UCY)	Students	7	3	4	25	7	**46**
23	Alternatives to sugar	Germany (UBO)	Students	6	6	3	18	9	**42**
24	Getting fit by traveling on a bus	United Kingdom (UCL)	University	6	10	6	0	0	**22**
25	Crime scene	Germany (UBO)	University	11	7	0	23	0	**41**
26	Marketing Chief	Finland (UEF)	No information	0	7	0	0	0	**7**
27	How will Cola-Co exist in 5 years?	United Kingdom (UCL)	University	0	0	0	0	3	**3**
	Total		**183**	**143**	**97**	**264**	**48**	**735**	

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For evaluation of the scenarios, an instrument was created (see Kotkas, Holbrook, & Rannikmäe, 2017; http://www.scientiasocialis.lt/jbse/?q=node/617; Kang, Keinonen, Simon, Rannikmäe, Soobard, & Direito, 2018; https://doi.org/10.1007/s10763-018-9930-y). It contains 28 items, in which students are asked to evaluate items on a 4-point scale (totally disagree - totally agree) for items 1-22, and on a 3-point scale (no, cannot make up my mind, yes) for items 25-28. Furthermore, two background knowledge questions about the topic of the scenario and careers (items 23 and 24) are included, to be answered using a 3-point scale (nothing, a little, a lot).

Based on the theoretical background, items 1-6, 23 and 24 focus on knowledge-triggered interest, while items 7-17 focus on value-triggered interest (Hidi & Baird, 1986). The value-triggered interest category of statements are divided into the subcategories ´impact level´, ´connectedness with a future career and studies´ and ´science for everyone.´ (Kotkas, Holbrook & Rannikmäe, 2016). Additionally, statements 18-22 measure how scenario attributes impact on students´ perceptions about the scenarios. This is included noting that the scientific literature indicates the way information is presented affects the reaction to information (e.g. Bergin, 1999). The open-ended questions to the questionnaire are included to gain understanding of the reasons why students consider scenarios as interesting, relevant, motivating or likeable. This allows researchers the possibility to understand how students think about the topic under investigation (Johnson & Christensen, 2000).

In the first stage, the initial instrument is piloted with 143 students. The internal reliability is calculated over all items, resulting in Cronbach $\alpha = 0.88$. In the second stage, partners from MultiCO project evaluate altogether 27 scenarios, which are developed by the time the evaluation process took place.

All created scenarios were presented to students. Students' perceptions were collected through a questionnaire and through group discussions within workshops (20 students in a classroom, and 20 in an after-school, context). Discussions of student groups (3-5 students per group) during the workshops were audiotaped. For scenarios which were videos, or animated PowerPoint presentations, students used computers, or tablets to evaluate. All scenarios were translated into the students´ native language. In this regard, the technical problem of translating videos was solved by supplying the translations on paper. However, in this case, students did provide feedback indicating that it was not as easy to follow the scenario in a video format, having written translations on paper, compared to having voice-over translations, or subtitles.

The comparative data analysis was carried out at two levels – by item/question and by category.

Analysis at the item level

To determine which scenarios were valued highly by students, means (based on the 4-point scale, giving a mean score above 2.5 for a positively valued scenario and a mean below 2.5 for a scenario valued negatively) and standard deviations were calculated for each item in the questionnaire for the four scenarios evaluated in common.

Analysis of open-ended questions

To analyse responses given to open ended questions, inductive codes were developed and categorised. Category descriptions were developed, based on the students´ responses. The categories were validated by three international experts. The agreement between the experts was greater than 90%.

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For data analysis, all scenarios for which there were less than 10 evaluators, were omitted. In the first stage, data for all scenarios and all partners were analysed based on principal component analysis (PCA) with Varimax rotation (KMO=0,89; χ^2=5652; df=231, p<0,001) and means (M) and standard deviations (SD) calculated for all items (1-22). Outcomes for items 23 and 24 were reported separately, because those items were intended to collect background information. The instrument also consisted of 4 open-ended questions (25-28) and those are mainly analysed based on categorisations of students' responses. A similar analysis pattern was also reported for each partner country and also for the 4 scenarios evaluated by each partner.

As a first step, all responses, over all scenarios, were analysed (except those scenarios for which there were less than 10 evaluators). Based on the mean and standard deviation analysis over all scenarios and items, students from all 5 countries found, in general, scenarios to:

1. easy to follow (M=2.87; SD=0.79);
2. enabling gaining of new knowledge about the topics (M=2.84; SD=0.81);
3. be understandable (M=2.82; SD=0.80);
4. enabling students to understand the responsibilities of the persons in the career position indicated (M=2.75; SD=0.79);
5. including topics in scenarios seen as important for the whole world (M=2.75; SD=0.89);
6. in a liked format (M=2.69; SD=0.91);
7. enabling students to understand the skills that are necessary in the profession(s) targeted (M=2.62; SD=0.84);
8. including scientific problems in the scenarios were socially relevant (M=2.61; SD=0.88);
9. enabling knowledge gained from the scenario to be seen as useful in the future (M=2.59; SD=0.80);
10. enabling students to gain new knowledge about possible career(s) (M=2.58; SD=0.86);
11. enjoyable (M=2.53; SD=0.90);

Overall, students from all countries didn't agree that:

1. on topics seen as important for appreciating the work of the local community (town, country) (M=2.42; SD=0.86);
2. enabling knowledge gained from the scenario to be put into practice to solve problems (M=2.40; SD=0.81).
3. make it easy for students to relate with the situation described (M=2.38; SD=0.87);
4. scenario topics were important for learning school subjects (M=2.32; SD=0.82);
5. scenarios described the science community to which they can relate (M=2.17; SD=0.81);
6. their future studies at the gymnasium or university level might be connected to the topics covered in the scenarios (M=2.11; SD=0.83)
7. scenario topics were important for them personally (M=2.11; SD=0.86);
8. they needed to perform science-related skills, described in the scenarios, in their future careers (M=2.10; SD=0.83);
9. scenario topics were important to their families (M=2.06; SD=0.86);
10. they needed to perform skills, described in the scenario, in their future careers (M=2.05; SD=0.82);
11. their future career might relate to the topics covered in the scenarios (M=1.96; SD=0.83).

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The student perception responses, related to the 22 items developed to cover knowledge triggered (1-6), value triggered interest (7-17) and scenario attributes (18-22), actual relate, based on factor analysis, to perceptions of scenario attributes, importance for a career , importance of the scenario topics and relevance related to a career (Table 8). Other further varied components are also suggested from individual country analyses.

Table 8. Questionnaire items within the various common components and country specific components related to the scenarios evaluated in common overall and towards each of the 4 specific scenarios

Type	Component 1	Component 2	Component 3	Component 4	Component 5
Overall	Importance of the topic	Importance for career	Scenario attributes	Relevance for career	
Partners					
Estonia	Importance for career	Scenario attributes	Importance of the topic	Relevance for society	Relevance for career
Finland	Relevance for society	Importance for career	Scenario attributes	Relevance for career	Relevance of the topic
Germany	Scenario attributes	Importance for career	Relevance for career	Relevance for society	Importance for the society
United Kingdom	Importance for career	Scenario attributes	Relevance for career	Relevance for society	Importance for the society
Cyprus	Relevance for society	Importance for career	Scenario attributes	Relevance for career	Importance for the society
Scenarios					
Earthquake red alert	Scenario attributes	Topic relevance	Relevance for society	Importance for career	Importance for the society
Electricity in the air	Relevance for society	Importance for society	Scenario attributes	Relevance for career	Importance for career
Solar power	Relevance for society	Importance for career	Relevance for career	Importance for society	Scenario attributes
Alternatives to sugar	Scenario attribute	Importance for career	Career relevance	Subject attributes	Personal relevance

The overall feedback from students during the evaluation process shows that:

- Students did not have enough time to evaluate more than two scenarios
- Some scenarios were very boring and hard to understand
- The translation sheets were important
- It was hard to evaluate some questions (for example, career related questions, students don’t know who they want to be in their future).

The overall feedback from teachers shows that:

- Some students didn’t look through their scenarios
- Students did not have enough time
- Teachers and students had problems with Google Drive (uploading process to Google Drive site was too long almost 24 hours/ problems with students e-mail addresses, e.g. didn’t remember their passwords)
- Two teachers were needed, because students had so many questions and they needed teachers help with the computer programs.
- Some scenarios were too hard to understand for seventh graders.

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In different events for public, scenarios were presented although public' perceptions were not collected systematically. This task was not seen relevant for the development of scenarios. Students in voluntary after school STEM classes or in special STEM classes were also asked to evaluate scenarios. As a first step, all responses from these STEM classes, over all scenarios, were analysed. Based on the mean and standard deviation analysis over all scenarios and items, special STEM class students from all 5 countries found, in general, scenarios to:

1. be understandable (M=2.99; SD=0.74)
2. enabling gaining of new knowledge about the topics (M=2.91; SD=0.66)
3. easy to follow (M=2.88; SD=0.79)
4. enabling students to understand the responsibilities of the persons in the career position indicated (M=2.88; SD=0.79)
5. including scientific problems in the scenarios were socially relevant (M=2.88; SD=0.79)
6. enabling students to understand the skills that are necessary in the profession(s) targeted (M=2.87; SD=0.82)
7. including topics in scenarios seen as important for the whole world (M=2.86; SD=0.84)
8. enabling knowledge gained from the scenario to be seen as useful in the future (M=2.66; SD=0.83)
9. enabling students to gain new knowledge about possible career(s) (M=2.65; SD=1.00)
10. in a liked format (M=2.51; SD=0.90)

Overall, students from all countries didn't agree that:

1. make it easy for students to relate with the situation described (M=2.45; SD=1.04)
2. enabling knowledge gained from the scenario to be put into practice to solve problems (M=2.42; SD=0.79)
3. scenario topics were important to their families (M=2.34, SD=1.04)
4. scenarios described the science community to which they can relate (M=2.30; SD=0.80)
5. scenario topics were important for learning school subjects (M=2.29; SD=0.82)
6. on topics seen as important for appreciating the work of the local community (town, country) (M=2.27; SD=0.89)
7. enjoyable (M=2.20; SD=0.90)
8. they needed to perform science-related skills, described in the scenarios, in their future careers (M=2.15; SD=0.82)
9. scenario topics were important for them personally (M=2.13; SD=0.85)
10. their future studies at the gymnasium or university level might be connected to the topics covered in the scenarios (M=2.11; SD=0.90)
11. they needed to perform skills, described in the scenario, in their future careers (M=1.99; SD=0.82)
12. their future career might relate to the topics covered in the scenarios (M=1.82; SD=1.01)

When comparing scenario evaluation in classroom settings and after school STEM classes, it can be seen that students agreed and disagreed with almost the same statements (only exception is item related to idea that scenarios were enjoyable).

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4.3 Collection of scenarios

Scenarios were modified and new scenarios created during the three years longitudinal study through design-based. Some possibilities, which are not intended to be exhaustive, for scenarios are:

1. An industry visit (purpose of the visit can be descriptive or problem-oriented)
2. Virtual scenario (e.g. a video showing work in industry, or a video of a visit pointing out different aspects)
3. A career story (given as a text, cartoon, or maybe role play such as involving interviews)
4. An issue (socio – scientific), or a problem (science related), which includes career-related aspects
5. Problem (industry linked, science-related)

Career should not be directly presented in all cases, can be hidden in an industrial or in any other science & technology related context.

Reflecting on the 'Title' of the scenario, it is suggested that the title itself needs to be motivational (at least for most of the students):

1. In general, the title avoids the inclusion of science concepts (not all students might be interested in learning science).
2. It avoids inclusion of unfamiliar or abstract concepts/words
3. The title does includes a statement, a problem or an issue related to students' everyday life
4. The title may be presented as a question.

The total number of scenarios created in MultiCO project until November 2018 for public use is 32 and can be found on the project website (www.multico-project.eu). The layout of the scenarios is under preparation.

5. Implementing scenarios

The MultiCO project investigated whether career-based scenarios in secondary science classrooms can have an impact on students' interest in appreciating science as an option for further study and as a career. This chapter considers the question 'What good practice has been shown during the interventions?'. Knowledge about science-related careers, working life skills and desirable scenarios has been used in planning instruction integrating career-based scenarios and inquiry-based learning. The main research question is:

What factors affect student motivation, interest, relevance and attitudes towards learning and what are the impacts of using a context approach in secondary school science?

Partners were encouraged to take into consideration design hypotheses for building scenarios into interventions (next phase in the project following scenario creation). These design hypotheses were drafted based on the results of the preliminary examinations and tested within the frame of the formative evaluation. Design principles emerge from design hypotheses once results from design-based research studies capture the lessons learned from testing and

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refinement. The design hypotheses refer to the design of the scenarios for interventions and take into consideration (a) The development of interests, (b) The practicality in school and (c) The learning of profession, these also present the core focus.

The hypotheses were as follows:

Hypotheses related to pupils' interest development

1. The scenarios should present students with the possibility to become actively engaged ("hands on" and "minds on").
2. The scenarios should entail team work.
3. The scenarios should take into consideration student's expectations.
4. The scenarios should involve more differentiated tasks that meet different performance levels.
5. The students should be provided with enough time to process each scenario.
6. The scenarios should maintain a local reference.
7. The scenarios should provide sufficient comprehension aids (supporting materials) when the original language, e.g. of audio files, is maintained.
8. The scenarios should present problems that students encounter in their everyday lives.
9. The scenarios should offer to students substantial decision-making possibilities in terms of content and methods.
10. The scenarios should enable students to take on a professional's role.
11. The scenarios should provide students with the opportunity to take over responsibility for solving the issue.
12. The scenarios should encourage students to debate with each other.
13. The title of the scenarios should awaken students' curiosity.
14. The scenarios should be diverse in terms of form, methods and subjects.
15. The scenarios should include riddles or problem solving activities.
16. The scenarios should come across as realistic (genuine) and authentic as possible.
17. The scenarios should implicate globally relevant issues.
18. The scenarios should contrast strongly with the regular lessons/curriculum.

Hypotheses related to practicability in the context of school

1. The texts presented in the scenario should be short.
2. The performance of the scenarios should be self-explanatory.
3. The scenarios should be directly applicable.
4. The performance of the scenarios should be as little teacher dependent as possible.

Hypotheses related to future careers

1. The scenarios should demonstrate authentic and specialist practices to the students.
2. The scenarios should illustrate young adult's professions (opportunity for identification).
3. The scenarios should animate students to overcome stereotypes.
4. The scenarios should include male and female scientists.
5. The scenarios should demonstrate the career paths of people working in the presented professional field / professions.
6. The scenarios should include a constructive activity with the presented professions.
7. The scenarios should allow students to meet professionals.

The specific research questions relevant to interventions were discussed in the second partnership meeting (UK, February 2016) as a starting point to outlining the methodology that would be implemented across the partnership. Those questions are summarised here, with some ideas about how they are being addressed in the intervention work and wider project:

How do teachers work with career-based scenarios in enriching science teaching and learning?

- What choices do teachers make regarding scenarios, and what are their reasons for this choice? (could be teachers' ideas about careers/learning/interest/what fits the curriculum).
  (Data source: Notes from planning meetings, teacher interviews)
- Where does the scenario fit into the teaching module? Reasons for plans (Notes from planning meetings)
- How is the scenario presented to students and what follows in the teaching approach? (Observation)
- How do students respond to/interact with the scenario? (Observation and interviews with students)
- How do teachers reflect on the scenario as part of teaching and learning? (Teacher interview)

What is the influence of career-based scenarios on student engagement and situational interest in science learning? (Analysis of observations, scenario questionnaire)

- To what extent does awareness of life-skills enhance students' interest in science learning? (Analysis of various strands of project)
- Design-based research approaches to enhancing students' awareness of science careers: what are the main challenges? (Analysis of intervention)

The design-based research used in five subsequent interventions in each country combines iterative design, research and practice in order to develop both theoretical insights and practical influences (Wang & Hannafin, 2005) so as to yield research results that have better potential for influencing educational practice, while the designs can be adopted elsewhere and the research results can be validated through subsequent use (Barab & Squire, 2004). The research process is managed, designed, implemented and systematically refined in collaboration with practitioners (e.g. teachers, students) in order to advance pragmatic and theoretical aims simultaneously (Wang & Hannafin, 2005; The Design-Based Research Collective, 2003; Barab & Squire, 2004). The importance of local context is not only affecting the research, but cultural aspects and the changes in local context arising from the design experiments are necessary, though not sufficient, evidence for the viability of a theory (Barab & Squire, 2004).

The intervention studies undertaken within the partnership show how scenarios can be selected and incorporated into science lessons to bring about student interest and motivation. From data collected from each intervention research teams have analysed the findings taking into account multiple factors. Based on this, common features, which are recommended in career-based, scenario selection and implementation, are:

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- A scenario needs to be short enough so that it can fit into lesson structures and sequences to allow for links to curriculum content and science inquiry.
- The scenario needs to be well structured, clearly linking content and careers.
- The context needs to relate to students: often this means involving people who are young as role models, involving local contexts and using examples that make reference to students' everyday culture in the modern world.
- It is preferable that scenario-based career discussions continue within or after the inquiry stages. Though scenarios are intended to be the initial motivating trigger, their impact on learning needs to be consolidated by reference to them during the lesson, or sequence of lessons.
- Scenarios can raise career awareness and are more likely to have an impact on this if they include several careers rather than only one.
- Where possible, it is advantageous to include students' own ideas and activities related to careers by involving them in scenario development.
- A common finding among partners is that scenarios which include visits (out of school), and/or include assignments for students, are particularly stimulating.
- When out of school visits take place, it is important that students are able to relate to the experts they meet so as to optimise identification of the expert's role. The experts need to be able to work with young people.
- Scenarios need to include discussion about values (for example social and ecological sustainability), making science studies more relevant to students.

In creating a model for scenario development and implementation, the partnership takes into account authentic and real/life socio-scientific issues, set in local contexts that address global challenges and include science-related careers. These aspects feed into the processes of introducing a potentially student-relevant concern, introducing science-related careers, linking these to science inquiry learning and, where possible, out of school visits. These processes need to take into account the curriculum expectations and teachers' confidence in handling career-based scenarios in their lessons, plus their willingness to manage out of school visits. Teachers also need to have awareness of the features that students find engaging, including appropriate careers that are accessible to students of varying academic achievement, and career roles with which students can identify. Also recommended is the integration of relevant working life occupational skills within scenario implementation, as how students perceive achievement of such skills to be important in science-related careers is more likely to lead to aspirations regarding those careers. Thus, a good scenario includes an issue to be resolved in a context, an introduction to careers and leads to an inquiry setting and consolidation to further promote curriculum competences.

Within the project, partners used similar methods to collect and analyse data from various sources e.g. through scenario questionnaires, lesson observations and interviews with students and teachers. The quantitative data illustrated students' interest in the scenario topic and specific learning features, whereas the qualitative data showed students' and teachers' reflections on the scenario implementation and follow-up (inquiry and consolidation) experience.

The findings from partners' interventions were used to capture what could be seen as 'good practice' in using career-based scenarios. Good practice was taken to be that which motivated students to study, raised their awareness of careers, and also enabled teachers to gain

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satisfaction with their pedagogic practice towards achieving their objectives. Also, as partners recognised that teachers should be able to modify a given scenario according to students' needs and interest, good practice involved students appreciating the scenario as relevant and interesting. Features of good practice were emphasised across the partnership in ways that were exemplified in the following country reports. As partners had different contexts and time spans for incorporating scenarios within interventions, these interventions differ in structure. However, such differences afford rich insights into the possibilities of using career-based scenarios in science teaching and learning.

In conclusion, the countries exemplified 'good practice' in very similar ways, but there were some differences in terms of how practice was implemented and thus in how good practice emerged. Findings show that to enable students to gain authentic and realistic impressions of workplaces, people and tasks in science careers, one possibility is to give them the chance to discover those in the real world outside the classrooms. In this connection, it is advisable to choose

(a) those careers and workplaces with which students are not familiar, i.e. not connected to a stereotypical image of a scientist (e.g. rather a male profession, a 'lone wolf's' work)

and

(b) workplaces which can be reached easily from schools. This aspect has the advantage that, by visiting such an out-of-school setting, the students get insights into their surrounding area and explore the importance of these workplaces for themselves, their city or society in general – what may lead to an even higher connection to a professional field in science. Another important aspect is the close cooperation with the experts at these workplaces – not only during the planning phase, but also during the intervention itself (the teacher stepping back and being a part of the learning group).

Good career-based scenarios include need, at least a topic that is of concern (a socio-scientific issue or problem) and a career setting, both leading to a scientific inquiry activity and followed up by consolidation of the intended learning, geared to the concern, the science learning and the science-related career(s). Table 9 shows how intervention examples include these aspects, the scenario (first two phases) leads to inquiry and activity (next phases).

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Table 8. Aspects of good scenarios

	UBO 'The mysterious case of Juliana'	UEF 'Coal to the teeth'	UCY 'Save the Polar Bears'	UCL 'Chemical Design Engineer'	UT 'Should there be a sugar tax? '
Scenario					
Concern or issue	The teacher shows a photo of a crime scene. The students have to solve the 'criminal case'. They can chose an expert to help them and receive five short career profiles. After justifying their choice, they are given the expert's report on the case. Only the electrician helps to finally solve the case (lethal electric shock).	Dentist sets the concern about the value of the toothpaste in the video (see below) shown to students.	The teacher shows the video with the starving polar bear, a discussion unfolds around the social issue, the science behind it, policy relevance, climate change consequences and how we could take action in our daily lives.	The teacher gives students details of two different injuries (one that has just occurred and is painful and swelling and one that is older and causing a dull ache). The students then design two different packs addressing the concern as to what to place on the injured areas (one exothermic for an older injury, one endothermic for a recent injury).	Students visit a lemonade company and walk around between multiple departments, getting familiar with work tasks and asking questions from staff members. In classroom settings after the visit, a slide presentation is shown to students to consolidate their experiences and consider the implications associated with introducing a sugar tax.
Introduc-tion to Science-related Career(s)	The scenario introduces five careers, each of them relating to one piece of evidence in the photo: Zoologist, Forensic Chemist, Electrician, Horticulturist, Pharmacist	Teacher shows a video of dentist's work.	The discussion focuses on insulation by presenting the students' mission to design energy efficient houses and the relevant experts: architect with specialiazation in energy-efficiency and phycisist specialized in Mechanical and Manufacturing Engineer.	The scenario introduces the work of a chemical design engineer, Nadia, via a series of powerpoint slides which explain her work and career history.	Multiple careers within the lemonade company are introduced during the visit (chemist, biochemist, logistics officer, marketing specialist, etc).
Inquiry and task					
Inquiry	The students search for information about different electricity topics (e.g. fuse types, dangers of electricity) and prepare a short presentation.	Teacher guides the inquiries; Students have the opportunity to plan their own inquiries.	The teacher divides the students in three groups. Each group has one wooden box used as a model house, three surfaces of different materials to test, a temperature sensor and one laptop to record the temperature on the software. The students test one material at a time and record their measurements on their handouts. The teacher and the researchers act as facilitators.	The teacher gives the students a selection of different salts (some which get warmer and some which get cooler when added to water) and encourages them to test the salt to decide which ones to use in the different packs.	Teacher facilitates the tasks for inquiry related work (measuring pH; sugar glycose test; CO_2 concentration; degustation). Students divide roles within a group for undertaking the inquiry related work.
Consol-idation Learning Activity	Students discuss about how Juliana's death could have been prevented.	Create a video presenting findings related to the concern for the dentist and sending it to the dentist.	Each group announces the results and conclusions are made during class discussion about the most appropriate material to use for insulation.	Students add their results to a table on the board and a class discussion takes place consolidating the science learning.	Designing a 'perfect' lemonade by a group of students and developing advertisement for this drink. Group presentations to other students.
Other parts of the study process					
Career activities		Consolidating the career of a dentist; Dentists' video message thanking students for their insights.		Introduction to an example of the work of a chemical design engineer.	Asking questions related to career paths, needed knowledge, skills and attitudes associated with workers in the different departments. The workers within the lemonade company Follow-up discussions after the visit in classroom settings.
Inquiries the setting is related to	Electricity (Physics)	Carbon/activated charcoal absorbing colors/an abrasive substance (Chemistry)	Heat transfer/Thermal Insulation (Physics)	Exo and endothermic reactions (Chemistry).	Should there be a sugar tax? (Chemistry, Biology)

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Reflecting on the outcomes of interventions, it can be argued that an expert's interaction with the students must be carefully planned in collaboration with the teacher. This could help finding ways to communicate information that bridges the gap between theory and practice and also shares personal experiences related to the experts' job/career, thus establishing a connection with students' career interests. Scenarios play a central role in promoting competences and awareness about science-related careers among the students. These scenarios are created through stakeholder co-operation between scientists in education, experts from science fields and industry and involving also civil society organisations, non-formal science educators and students. This approach is based on social constructivism at both levels: learning and teaching. The following principles from Bruner's (1960) work were taken into account in developing the scenario:

- Instruction needs to be concerned with the experiences and contexts that make the student willing and able to learn (readiness). In MultiCO, the first stage involves creating a scenario for students to be able to relate to a real-life concern and seeking to trigger motivation to learn.
- Instruction needs to be structured so that it can be easily followed by students (spiral organisation, Bruner, 1960). In MultiCO scenarios, this is ensured by allowing students to ask questions during the scenario presentation, guided by the teacher and therefore the scenario presentation is in a collaboration between teacher and students.
- Instruction needs to be designed to facilitate extrapolation and/or fill in the gaps (going beyond the information given). In MultiCO, at the end of scenarios, students are faced with concepts or ideas, which are new to them and therefore this encourages them to prepare for learning new science content in the next phase.

In MultiCO, the scenario creation is approached with two different aspects in mind:

- The need to set ups the scenario as a situation, involving a concern or issue and presented in a student-relevant context to also allow focus on science-related career (students can have the opportunity to construct their initial ideas).
- The need to ensure meaningful progression from the scenario into actual classroom science teaching (considerations need to focus on the transitional teaching approach, recommendations on how best to get students involved in the learning and how to ensure the development of curriculum-related science competences e.g. a 'scientific' question to be investigated) – for this, teachers need to be involved in constructing the teaching component, beginning with the scenario.

Finally, special attention needs to be paid to the teachers' interaction with the students and their own engagement with the scenarios. Together, the partnership examples draw a rich picture of the different benefits the MultiCO approach has had in the five countries. While the teams have outlined, generally, different advantages of the scenarios, these implications are by no means exclusive to any of them and further similarities and differences may be explored in future outputs by the MultiCO team.

Individual interventions are reported in Country Reports (www.multico-project.eu) and in case study articles. Finnish teachers described in post interviews good scenario and its implementation as shown in Figure 6.

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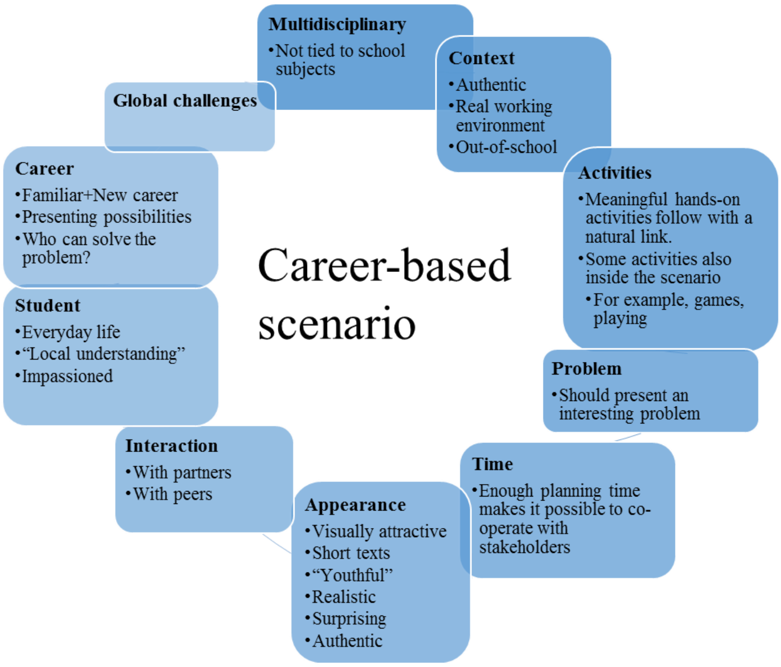

Figure 6. Good scenario and its implementation according to the Finnish teachers

6. Students' interest development during the interventions

Students' study and career choices were mapped out after the five interventions. Quantitative and qualitative methods were used. Data was collected by the post-questionnaire, students' interviews and workshops.

6.1 Interest development

Students' science interest development during the project period was measured by quantitative and qualitative methods. Before and after the project's interventions in schools (5 interventions in total; over 2,5 years), the students were asked to fill in a questionnaire. In addition to this longitudinal study, the students' situational interest was measured during and after each of the five interventions (Figure 7). Data was collected by observations, students' and teachers' interviews as well as by questionnaires. These cross-sectional studies are reported in D4.1-D4.4 and several case study articles.

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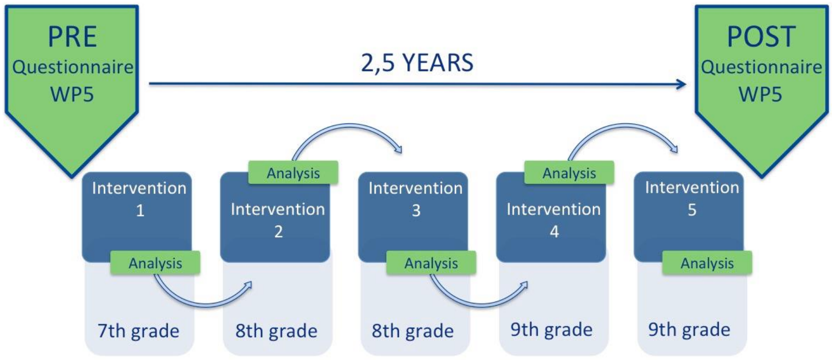

Figure 7. Studies on interest development in the MultiCO project (time chart)

Development of the questionnaire

To develop the pre/post questionnaire, altogether 52 items were chosen from existing scales (PISA, ROSE etc.):

- Interest in science learning related to subjects (OECD, 2009)
- Interest in science topics (ecology, health, food, energy, transport, other) (Schreiner & Sjøberg, 2004)
- Science interest in general (Frenzel et al., 2012)
- Affective factors (Owen et al., 2008)
- Enjoyment of science learning (OECD, 2009)

The questionnaire was tested on a dataset from the five partner countries (N=1031). First, the interitem correlation was tested, and 35 items were deleted from the analysis due to low or very high correlations. After exclusion, the determinant of the correlation matrix between all remaining items was >0.00001. The 17 remaining items were used to conduct a principal component analysis with orthogonal rotation (varimax). The Kaiser-Meyer-Olkin measure supported the sampling adequacy for the analysis KMO= 0.93, and all individual items achieved a KMO >0.89. Bartlett's test of sphericity, $\chi 2(136)= 8550$, $p<0.001$, indicated sufficient high correlations between the items. An initial PCA reveals eigenvalues from the data. Regarding the high sample number, the Kaiser's criterion was used in addition to the interpretation of a scree-plot. Four components showed eigenvalues >1.0 and explained 66% of the variation.

The 17 items clearly load on four different factors which can be characterised as i) an emotional component, a knowledge component subdivided into ii) technology/sustainability topics and iii) health topics, and iv) a value component (personal value as well as value for society). Cronbach's α indicated acceptable internal consistency for all scales.

In addition to the 17-item science interest scale, the questionnaire also included items reflecting influencing factors, such as the students‘ self-concept (six Items) and the students‘ participation in out-of-school science-related activities (eight Items). Another item set referred to the students‘ perception of school science lessons (12 items, only part of the post questionnaire), divided into four parts:

- Preparation for science careers (4 items)
- Information about science careers (4 items)
- Relation to the students' everyday life (2 items)
- Relation to current societal and global challenges (2 items)

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Data collection and analysis

The data from all partners was collected using an excel sheet. In this data sheet, codings were provided to distinguish between different student groups. The pre questionnaire was completed by 1031 students from the five partner countries (56% girls, 44% boys, mean age 13.0 years) and the post questionnaire by a similar number of students (N=1023 with 54% girls and 46% boys) (Table 9). For the analysis of the students' science interest development, the pre and post questionnaires were aligned by individual codes. In total, 678 students (48% girls, 50% boys) could be correctly matched. From these 678 students, 415 had taken part in the MultiCO project (=intervention group), 263 had only completed the two questionnaires but not participated in the interventions (=non-intervention group). Within the intervention group, two subgroups were distinguished: students which developed scenarios themselves (='Scenario creators', 309 students) and those who only attended MultiCO science lessons but did not develop any scenarios themselves (='Non-creators', 106 students).

Table 9. Details of the collected set of data

Datasets	Subgroups	Number of participants	Gender distribution (%)	Mean Age (range)
Pre questionnaire	**Total**	1031	576 female (56%); 455 male (44%)	13.0 (11-17) years
Post questionnaire	**Total**	1023	549 female (54%); 475 male (46%)	15.2 (14-18) years
	Intervention	490		
	Non-Intervention	479		
	Scenario creators	403		
Longitudinal data (pre & post data aligned by IDs)	**Total**	678	331 female (48%) ; 341 male (50%)	
	Intervention	415	208 female (50%); 203 male (49%)	
	Non-Intervention	263		
	Scenario creators	309		
	Non-creators	106		

For the data analysis, we focused mainly on the intervention group and differences between the partner countries. The structure and foci of the country reports as well as the data provided by the different countries were very heterogeneous. UCL, for example, was able to distinguish more student subgroups than the other partners (e.g. subgroups according to the number of interventions the students had been involved). Therefore, a comprehensive alignment of data and analysis steps had to be conducted in order to bring together national findings. To ensure comparability within the comparative dataset, the group definitions had to be adjusted in some datasets, which results in slightly diverging findings between the overall comparison and the individual country reports. To be able to interpret the data on the students' science interest development accurately and comprehensively, qualitative and quantitative data will need to be combined.

Additionally, differences between school types or gender should be taken into account. All subsets of data were tested on normality by Shapiro-Wilk tests, and, if normal distribution was given, on homogeneity of variance by Levene tests. For comparisons of means, Wilcoxon rank sum tests and dependent t-tests were used. All stated mean values have to be interpreted in relation to a theoretical mean of the Likert scale of 2.5.

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To visualise the multidimensional data of the interest development, a non-metric multidimensional scaling ordination technique (NMDS) was used. To check for significant shifts in the data from pre to post conditions, a robust multivariate analysis of variance test (MANOVA) with adjacent discriminant analyses was used. Correlations between influencing factors and interest in science have been detected using generalised additive models (GAM), which add smoothed functions to the data and test for the goodness of fit.

Interest development in the intervention group

During the 2.5 years of the MultiCO project time, the interest in science increased significantly in the intervention group (pre: M= 2.66, SD=.55; post: M= 2.79, SD=.51; p<.001, r=-.16; Figure 8). Investigating the different aspects of interest, a significant increase could be revealed for all subcomponents. However, only the changes in the emotional aspect (pre: M= 2.50, SD=.81; post: M= 2.67, SD=.80; p<.001, r=-.15), the value aspect (pre: M= 3.16, SD=.63; post: M=3.33, SD=.66; p<.001, r=-.19) and the knowledge aspect regarding health topics (pre: M= 2.88, SD= .78; post: M= 3.01, SD=.74; p<.01, r=-.15) were characterised by small effect sizes, whereas the knowledge aspect regarding technology and sustainability topics showed a negligible effect size (pre: M= 2.44, SD= .67; post: M= 2.51, SD=.69; p<.05, r=-.07) (Figure 8).

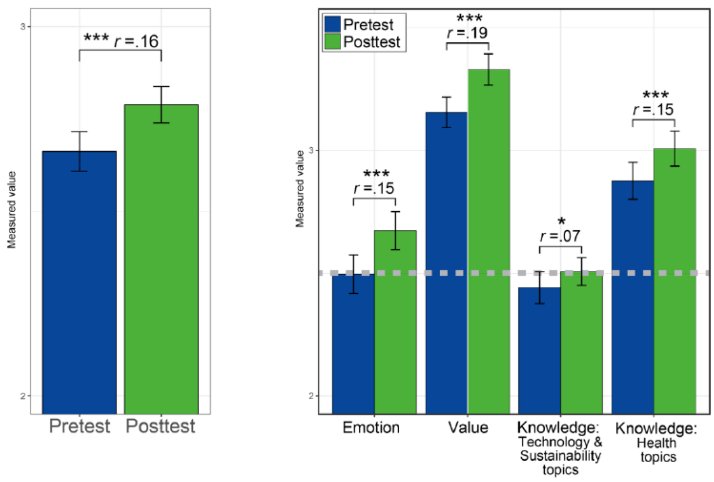

Figure 8 (left). Comparison between the students' science interest (N=415) in the pre and post test (pre: *M*=2.66, *SD*=0.55; post: *M*=2.79, *SD*=0.51); (right): Interest development (N=415) in relation to the three aspects of interest (Emotion pre: M= 2.5, SD= 0.81; post: M= 2.67, SD= 0.80; Value pre: M= 3.16, SD= 0.63; post: M= 3.33, SD= 0.66; Knowledge (Techn.& Sustain.) pre: M= 2.44, SD= 0.67; post: M= 2.51, SD= 0.59; Knowledge (Health) pre: M= 2.88, SD= 0.78; post: M= 3.01, SD= 0.74).

To visualise the shifts between the pre and post test, a Nonmetric multidimensional scaling (NMDS) ordination combines all scores from all subcomponents of interest in an artificial two-dimensional coordinate system (see Figure 9). The NMDS shows a shift of the focal points from pre to post conditions, which can be interpreted as a stronger emphasis on the emotional aspect in the post data. This shift is significant (robust MANOVA: *F*= 5.76, p=.003).

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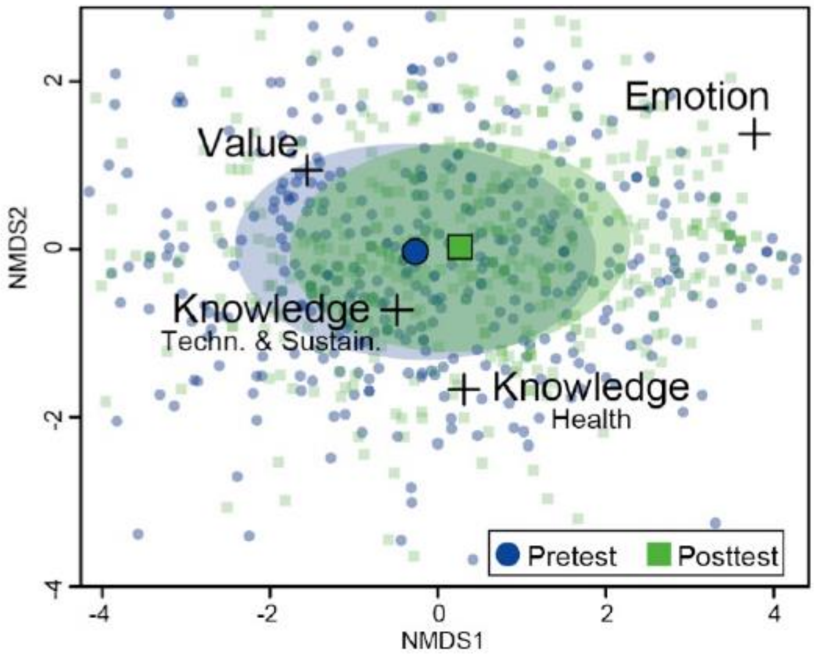

Figure 9. Visualisation of the interest development from pre to post questionnaire within the intervention group using a Nonmetric Multidimensional Scaling Ordination. Blue indicates pre questionnaire data with allocations of individual students by small symbols, main area of distribution by shade d circle and the focal point of all data points by big symbol. Likewise, green colour indicates post questionnaire data. The shift between both conditions is significant (F= 5.76, p=.003).

The impact of scenario creation on student's interest in science

The students who created scenarios themselves showed a significantly increased interest in science after the interventions (pre: M=2.60, SD= .50; post: M=2.76, SD= .55; p<.001, r=.20). For the noncreator group, in contrast, no increase in science interest could be measured (pre: M=2.85; SD= .57; post: M=2.86, SD=. 54; p=.39). In the creators' group, all aspects of interest increased significantly with small effects between r= .13 and .20 (see Figure 10). In the development of the non-creators' science interest, a significant shift in interest could only be measured in relation to the value aspect (pre: M=3.25, SD= .68; post: M=3.37, SD= .69; p<.05, r= .16).

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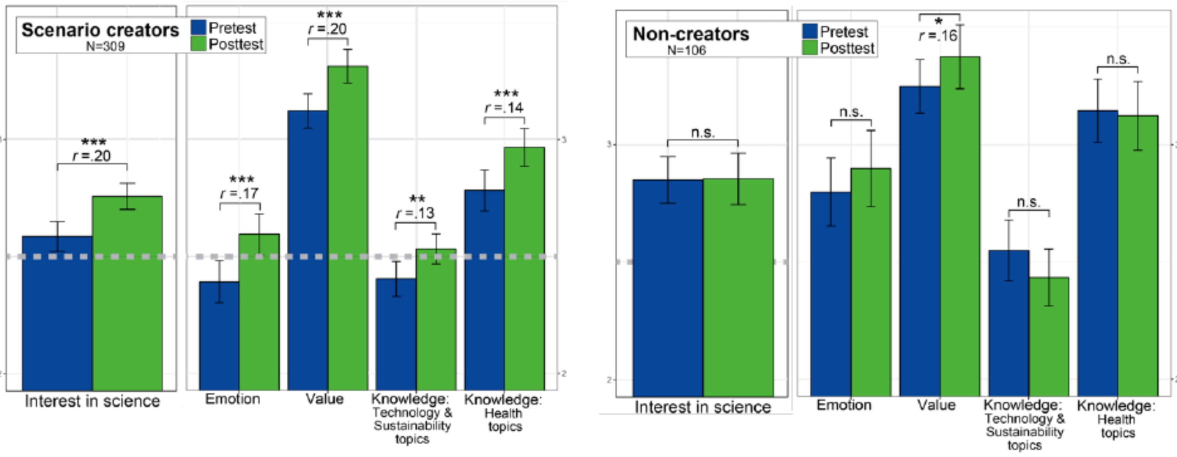

Figure 10. Development of interest in science contrasting the students who developed scenarios themselves (scenario creators, left) and those who did not (non-creators, right)

Influencing factors

In the post questionnaire data, the engagement in out-of-school science activities was significantly higher in the intervention group (*M*= 1.72, *SD*= .50) in comparison to the non-intervention group (M= 1.44; SD= .41) (p<.001) (Figure 11). Despite representing a medium effect size of r=.30 between both groups, however, in relation to the theoretical mean of 2.5, none of them is frequently engaged in science related activities in their free time. The students' science related self-concept as well was found to be significantly higher in the intervention group (M= 2.91, SD= .61) than in the non-intervention group (M=2.67, SD= .70) (p<.001, r= .18). The feeling that school science prepares them well for science careers does not differ between the intervention (M=2.94, SD= .55) and non-intervention group (M=2.90, SD= .08) (p=.34), but both groups rated distinctly above the theoretical mean of 2.5.

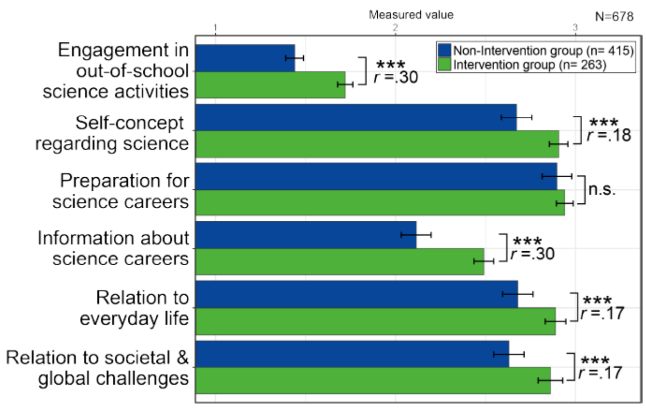

Figure 11. Differences in the post questionnaire data between the intervention (n=415) and non-intervention group (n=263) regarding engagement in out-of-school science activities, self-concept regarding science and the students' perceptions of school science lessons

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The information about science careers in the school lessons was rated significantly higher in the intervention group (M=2.49, SD= .64) than in the non-intervention group (M=2.11, SD= .68) ($p<.001$, r=. 30), representing a medium effect. A significant difference ($p<.001$) but only a small effect (r=. 17) could be measured for the perceived relatedness of school science to the students' own everyday life. The intervention group rated higher (M=2.89, SD= .68) in comparison to the non-intervention group (M=2.68, SD= .70). Likewise, the perceived relation of science topics in school lessons to global and societal challenges differed significantly between the intervention (M=2.86, SD= .80) and non-intervention group (M=2.63, SD= .70), however only showing a small effect size (r= .17). There are significant positive correlations between all influencing factors and the interest in science score retrieved from the post questionnaire data (see Figure 12). However, there are distinct differences between the four factors:

The engagement in out-of-school science related activities shows a significant positive correlation with the interest in science, both for the intervention group ($F(5)=37.8$, $p<.001$, R2(adj.)=.31) and the non-intervention group ($F(3)=49.2$, $p<.001$, R2(adj.)=.34). In both correlations, the proportions of explained variance by the model are quite high (31% and 34% respectively). The correlations are not linear in both cases and rise slightly towards higher scores. The higher the interest in science, the higher the impact on free-time science activities (or vice versa) in relation to lower scores.

The self-concept regarding science correlates significantly with interest in science in both groups (intervention group: $F(1)=116$, $p<.001$, R2(adj.)=.22; non-intervention group: $F(1)=73.5$, $p<.001$, R2(adj.)=.22). The correlation within the non-intervention group is nearly linear, whereas in the intervention group, a distinct positive bend can be observed, which means a more positive self-concept regarding science in combination with low interest score (or vice versa) compared to the non-intervention group. In both groups, the correlation model explains 22% of the variance.

In all school science related scores, positive linear correlations with interest in science were found (preparation for science careers - intervention group: $F(1)=98$, $p<.001$, R2(adj.)=.19; non-intervention group: $F(1)=43.7$, $p<.001$, R2(adj.)=.14 | information about science careers – intervention group: $F(8)=15$, $p<.001$, R2(adj.)=.20; non-intervention group: $F(2)=34.8$, $p<.001$, R2(adj.)=.17 | relation to students' everyday life – intervention group: $t=12.8$, $p<.001$, R2(adj.)=.28; non-intervention group: $t=8.2$, $p<.001$, R2(adj.)=.20 | relation to societal and global challenges – intervention group: $t=11$, $p<.001$, R2(adj.)=.18; non-intervention group: $t=6$, $p<.001$, R2(adj.)=.12). Investigating the correlation between the perceived preparation for science related careers in school science lessons and the students' interest in science, no difference in the correlation trends between intervention and non-intervention can be observed. In the correlation with the perceived amount of information about science careers in school lessons, parallel trends between intervention and non-intervention group were calculated. For the scores of the perceived relation of school science to the students' everyday life and societal and global challenges, intersecting linear correlation trends indicate relatively higher perceived relations in correspondence to high interest (or vice versa) in the intervention group. Low perceived relations in combination with low interest (or vice versa) are indicated by the correlation model for the intervention group.

All correlations of the students' science interest with their perception of school science scores are weak (R2<.20), except of the connection between the relation of school science with their everyday life and interest in the intervention group with 28% explained variance.

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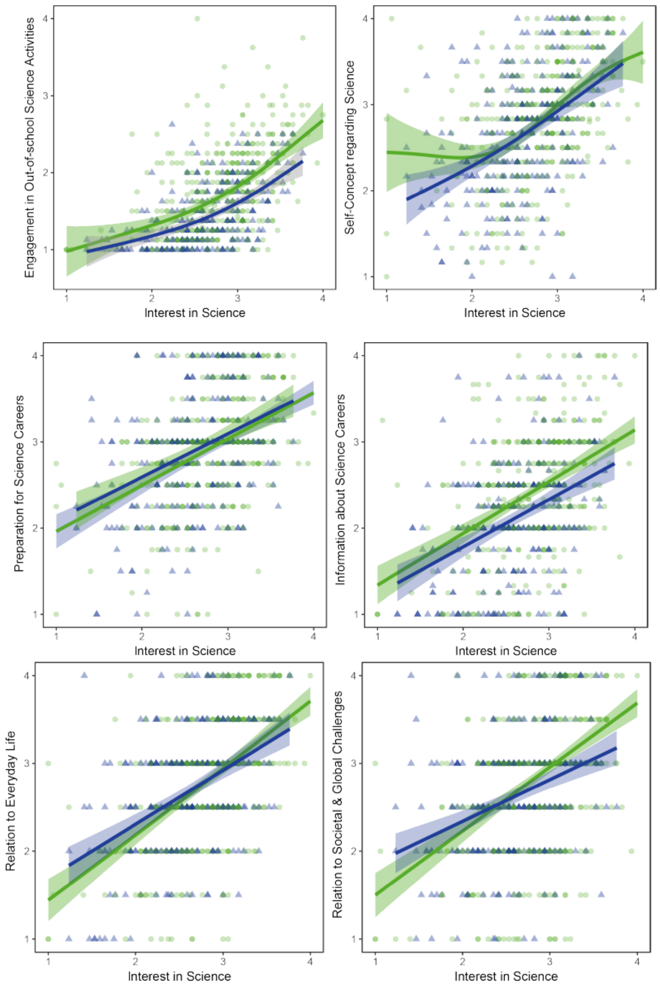

Figure 12. Correlation between the students' interest in science score retrieved from the post questionnaire data and different influencing factors, distinguished between the intervention group (green colour, N=415) and the non-intervention group (blue colour, N=263). The solid line indicates the GAM model fitting significantly to each subset of data, the shaded area represents the corresponding confidence interval.

Country comparisons

The students' interest development differs between the countries participating in the MultiCO project. Significant increases of interest were measured in the value aspect in England ($p<.01$, $r=-.22$), in all aspects in Finland (Emotion: $p<.01$, $r=-.22$; Value: $p<.001$, $r=-.23$; Knowledge regarding technology and sustainability topics: $p<0.001$, $R=-.30$; Knowledge regarding health topics: $p<.001$, $r=-.29$) and in the emotional ($p<.001$, $r=-.37$), value ($p<.01$, $r=-.25$) and the knowledge aspect regarding technology and sustainability topic components ($p<.05$, $r=-.14$). In Germany and Cyprus no significant change of interest within the intervention group was measured (Figure 13).

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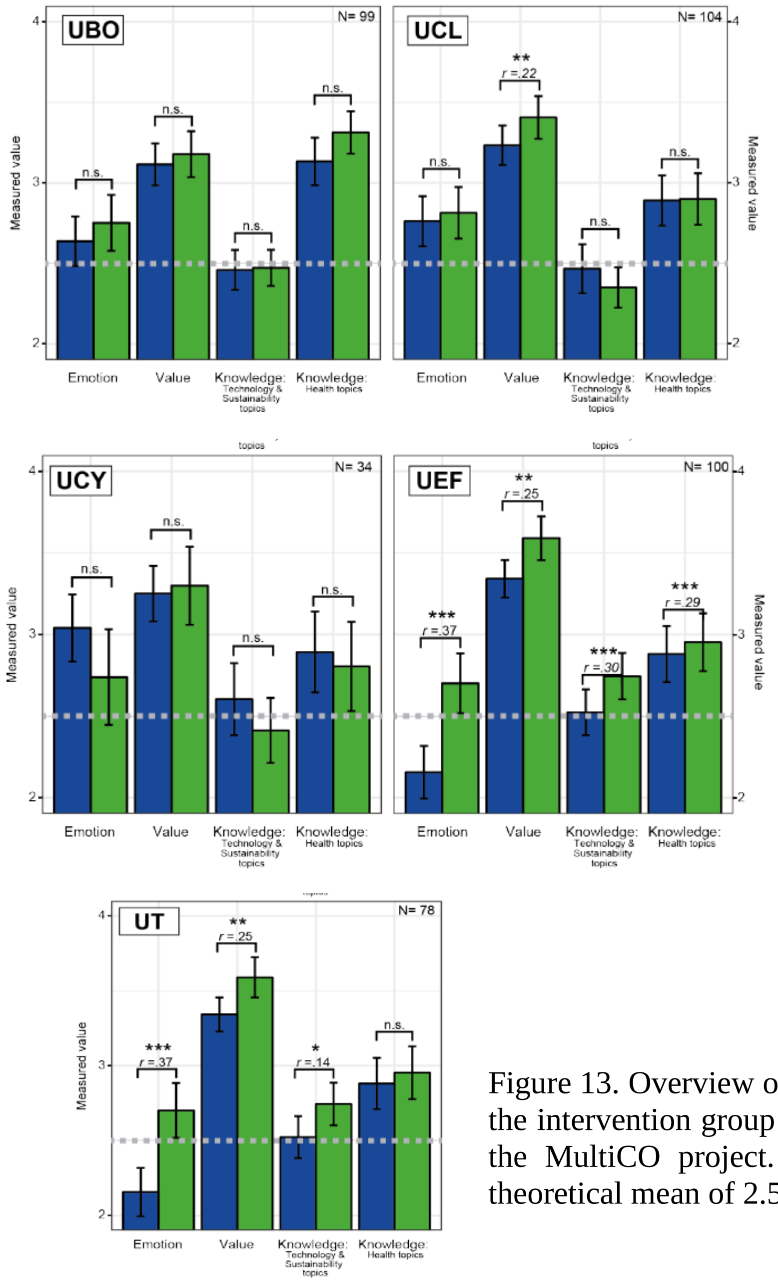

Figure 13. Overview of the interest development within the intervention group for each country participating in the MultiCO project. The dashed line indicates the theoretical mean of 2.5 on the used Likert scale.

Also the levels of interest are different in the partner countries with a significant lower level of interest in Finland ($H(4)= 34.7$, $p<.001$) in the pre test and significant differences between Estonia and Finland ($H(4)= 11.6$, $p= .021$) in the post test (Figure 14).

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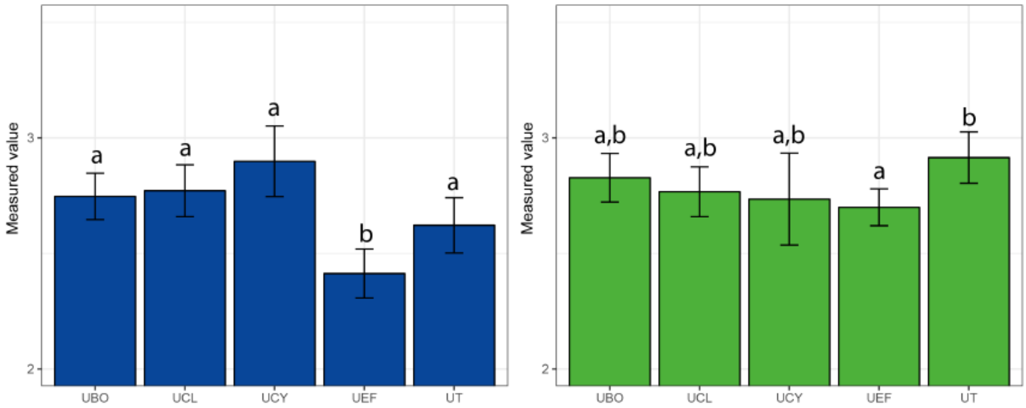

Figure 14. Level of interest in the five partner countries before (left) and after the interventions (right). Same letters indicate non-significant differences between the datasets (p>.05).

The students of the intervention group as a whole show a significant increase in science interest between the pre and post-test. This increase is significant for all aspects of interest except of knowledge (technology & sustainability topics). There is a stronger emphasis on the affective aspects of interest after the intervention.

The interest development is positively connected with the students' self-concept, their out-of-school activities, and their perception of school science. Comparatively strong relationships were found between the students' science interest and their engagement in out-of-school science related activities as well as the perceived relation of school science to their everyday life.

The students' interest development differs between the partner countries and should therefore be examined more closely on the individual country level. In Germany and Cyprus, there are no significant differences between the pre and post-test. In U.K., a significant increase has been shown in the value aspect of interest only. In Estonia, the data show a significant increase in the emotional and value aspects of students' science interest. Only in Finland, a significant increase in all the aspects of interest (emotion, value and knowledge) has been demonstrated.

The levels of students' interest in science differ between the partner countries (see D5.1), with Finland having started from a significantly lower level in the pre-test to almost reaching the same level as the other countries in the post test.

6.2 Students' study and career choices

Part 4 of the project's *post-questionnaire* included questions about the students' future studies after lower secondary school and the reasons behind them, science subject choices as well as their career aspirations. Due to constraints on conducting research with students in their final grade of compulsory schooling in U.K., UCL distributed and completed the post-questionnaire in February. After that Part 4 in the questionnaire was seen relevant to acquire information on career choices.

Students were *interviewed* after they had answered the post-questionnaire at UEF, UCL and UCY. These interviews followed a protocol developed by UEF. This interview

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protocol used the same themes as the post-questionnaire and its purpose was to get more information about the students' school subject, study and career choices. In addition, some partners added questions regarding the impact of the interventions and the whole project on students' subject and study choices and career aspirations. Students were chosen for the interviews based on their interest in science (grouped into 'interested in science', 'neutral about science' and 'not interested in science') based on questionnaire data (pre and/or post) and teachers' evaluation. UT and UBO were not able to conduct any interviews with the students due to time constraints at the end of the school year and exam periods in schools.

According to a suggestion made by UBO during the sixth project meeting in London, a *workshop* was organized by some partners (UEF, UBO & UCY) as part of this task. The aim of the workshop was to enrich post-questionnaire and interview data by prompting students to interact with each other in a non-conventional teaching setting. UEF, UBO and UCY followed a similar approach (Think-pair-share workshop) by having group/whole class discussion about their choices in regard to their school subjects, future studies and career aspirations as well as reasons for these choices based on a worksheet. After that, students' answers were collected in word clouds/AnswerGarden app to indicate the most important factors that influence their choices. UEF combined the workshop with a one-day visit to the University and SciFest science festival. UCL was not able to conduct the workshop but included relevant questions in the student interviews. Participants in the science study and career choice part are shown in Table 10.

Table 10. Participants in the choice study

Partner	Post-questionnaire	Workshop
UEF	116	121
UCY	38	38
UT	116	-
UCL	-	-
UBO	139	112

Summary of quantitative data – differences and similarities between countries

Post questionnaire

The majority of the participants in the four countries (UCL data not available) chose high school education as future studies (Figure 15). There were not any differences within the gender. However it is worth noting that in the case of Finland a relatively higher percentage of students (27%) opted for vocational school compared to the other countries. Table 11 displays the percentages of students' future study choices based on students' answers in the post-questionnaire.

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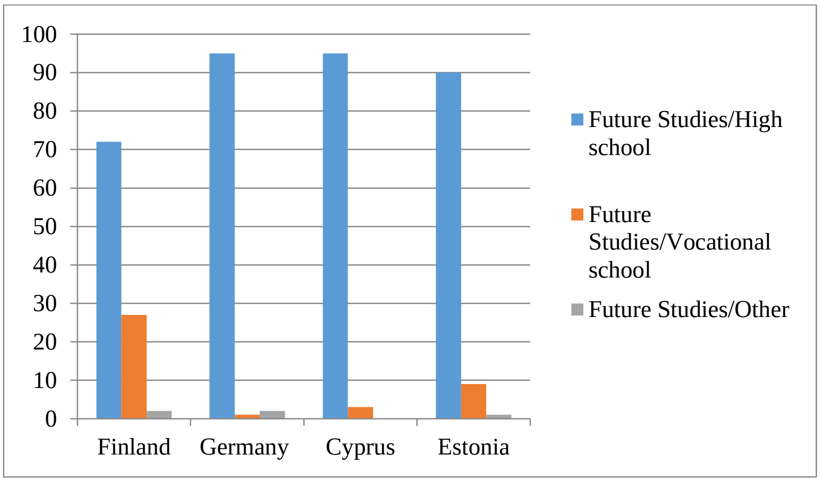

Figure 15. Percentages of students' future study choices per partner country

Table 11. Percentages of students' future study choices based on the post-questionnaire

Country	**Finland**			**Germany**			**Cyprus**			**Estonia**		
Gender*	F	M	Total	F	M	Total	F	M	Total	F	M	Total
% **(N)**	48 (56)	52 (60)	100 (116)	65 (91)	35 (48)	100 (139)	39 (15)	61 (23)	100 (38)	44 (51)	56 (65)	100 (116)
Future Studies/High sch.	47 (39)	53 (44)	72 (83)	66 (87)	34 (45)	96 (133)	39 (14)	61 (22)	95 (36)	45 (47)	55 (57)	90 (104)
Future Studies/Voc. sch.	52 (16)	48 (15)	27 (31)	0 (0)	1 (1)	1 (1)	0	3 (1)	3 (1)	30 (3)	70 (7)	9 (10)
Future Studies/Other	(1)	(1)	2 (2)	1 (1)	2 (2)	2 (3)	0	0	0	0	1 (1)	1 (1)
Mathematics/ Basic	53 (31)	47 (27)	50 (58)	68 (59)	32 (28)	63 (87)	50 (4)	50 (4)	21 (8)	27 (3)	73 (8)	9 (11)
Mathematics/ Advanced	37 (11)	63 (19)	26 (30)	60 (29)	40 (19)	35 (48)	34 (10)	66 (19)	76 (29)	46 (36)	54 (42)	88 (78)
Chemistry	60 (18)	40 (12)	26 (30)	68 (46)	32 (22)	49 (68)	55 (6)	45 (5)	29 (11)	41 (14)	59 (20)	29 (34)
Physics	64 (23)	36 (13)	31 (36)	37 (14)	63 (24)	27 (38)	47 (9)	53 (10)	50 (19)	44 (20)	56 (25)	39 (45)
Biology	30 (14)	70 (33)	40 (47)	68 (80)	32 (37)	84 (117)	53 (9)	47 (8)	45 (17)	45 (18)	55 (22)	35 (40)
Geography	25 (6)	75 (18)	21 (24)	66 (43)	34 (22)	47 (65)	33 (1)	66 (2)	8 (3)	39 (11)	61 (17)	24 (28)

*The percentages shown in the columns for each country are calculated with respect to the total sample in each country respectively and not within the gender sample. The numbers (N) are shown in parenthesis.

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The chart (Figure 16) illustrates the percentages of students' future study choices per partner country. As shown in the figure, in Finland, the majority of the students (40%) chose biology as a future subject as well as in Germany (84%). However, students' most popular subject choice in Cyprus and Estonia (Figure 16) was advanced mathematics with a major difference (76% and 88%, respectively). Physics was the second most popular choice in Finland (31%), Cyprus (50%) and Estonia (39%) whereas in Germany was chemistry (49%). Geography was the least popular subject choice in all the countries except Germany (47%).

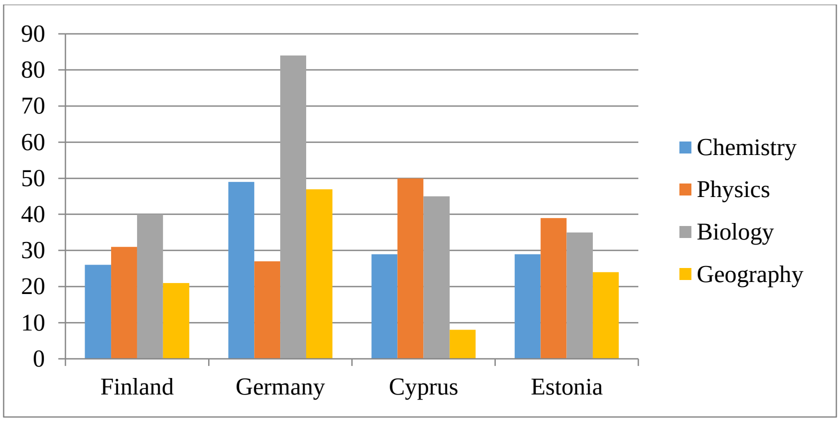

Figure 16. Percentages of students' future study choices with respect to chemistry, physics, biology and geography per partner country

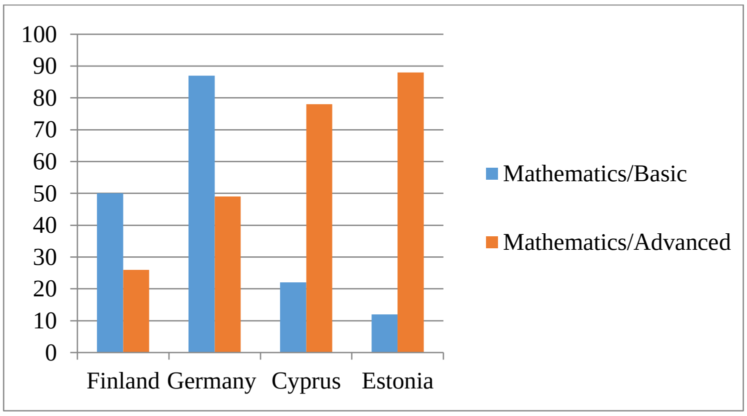

Figure 17. Percentages of students' future study choices with respect to mathematics per partner country

Further Analysis using a Chi-square test of independence was calculated comparing the subject choice between girls and boys. Differences were identified only in the case of Germany and Finland as follows:

Germany: a significant interaction was found (χ^2 (1,38) = 18.955, p <.001) with respect to the choice of physics between girls and boys. It was found that boys were more likely to choose physics (63%) than girls (37%).

Finland: It was found that girls were more into physics and boys chose more biology and geography studies. In particular:

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- a significant interaction was found ($\chi^2_{(1,36)} = 5.096$, $p < .05$) with respect to the choice of physics between girls and boys. Girls were more likely to choose physics (64%) than boys (36%).
- a significant interaction was found ($\chi^2_{(1,47)} = 10.817$, $p < .001$) with respect to the choice of biology between girls and boys. Boys were more likely to choose biology (70%) than girls (30%).
- a significant interaction was found ($\chi^2_{(1,24)} = 6.566$, $p < .05$) with respect to the choice of geography between girls and boys. Boys were more likely to choose geography (75%) than girls (25%).

Table 12 shows the percentages of students' future study choices within the gender per partner country.

Table 12. Percentages of students' future study choices within the gender per partner country

Country	**Finland**			**Germany**			**Cyprus**			**Estonia**		
Gender*	F	M	Total	F	M	Total	F	M	Total	F	M	Total
% (N)	48 (56)	52 (60)	100 (116)	65 (91)	35 (48)	100 (139)	39 (15)	61 (23)	100 (38)	44 (51)	56 (65)	100 (116)
Future Studies/ High school	70 (39)	73 (44)	72 (83)	96 (87)	94 (45)	96 (133)	93 (14)	96 (22)	95 (36)	92 (47)	88 (57)	90 (104)
Future Studies/ Vocational school	29 (16)	25 (15)	27 (31)	0 (0)	2 (1)	1 (1)	0	13 (1)	3 (1)	6 (3)	11 (7)	9 (10)
Future Studies/ Other	2 (1)	2 (1)	2 (2)	1 (1)	4 (2)	2 (3)	0	0	0	0	2 (1)	1 (1)
Mathematics/ Basic	55 (31)	45 (27)	50 (58)	65 (59)	58 (28)	63 (87)	27 (4)	17 (4)	21 (8)	6 (3)	12 (8)	9 (11)
Mathematics/ Advanced	20 (11)	32 (19)	26 (30)	32 (29)	40 (19)	35 (48)	67 (10)	83 (19)	76 (29)	71 (36)	65 (42)	88 (78)
Chemistry	32 (18)	20 (12)	26 (30)	51 (46)	46 (22)	49 (68)	40 (6)	22 (5)	29 (11)	27 (14)	31 (20)	29 (34)
Physics	41 (23)	22 (13)	31 (36)	15 (14)	50 (24)	27 (38)	60 (9)	43 (10)	50 (19)	39 (20)	38 (25)	39 (45)
Biology	25 (14)	55 (33)	40 (47)	88 (80)	77 (37)	84 (117)	60 (9)	35 (8)	45 (17)	35 (18)	34 (22)	35 (40)
Geography	11 (6)	30 (18)	21 (24)	46 (43)	34 (22)	47 (65)	7 (1)	9 (2)	8 (3)	22 (11)	26 (17)	24 (28)

*The percentages shown in the columns for each country are calculated within the gender sample except those shown in 'Total' column. The numbers (N) are shown in parenthesis.

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Quantitative Data (Worksheet/Workshop)

According to the quantitative data presented in the Table 13 from UBO and UCY, interest is the most influencing factor for subject choices as indicated by the students who participated in the workshop in UBO (93%) and UCY (74%). Nevertheless, in spite of the major difference in the participants' number between the countries (the number of UBO participants is nearly tripled than UCY participants), minor differences can be identified within the gender regarding the two countries. In particular, in the case of UBO, girls' percentage of choosing interest is higher (94%) than the corresponding of UCY girls' participants (67%) whereas in terms of career related reasons this was reversed.

Table 13. Percentages of Students' Reasons for Subject Choices (workshop-based data)

Country	N			Interest			Career-related reasons			Other reasons		
	F	M	Total	F % within gender	M % within gender	% of Total	F % within gender	M% within gender	% of Total	F % within gender	M% within gender	% of Total
Germany	78 (69%)	34 (31%)	112	94	88	93	45	50	46	21	15	19
Cyprus	15 (39%)	23 (61%)	38	67	78	74	67	52	58	7	9	8

* NOTE: Students were able to choose more than one option

Summary of qualitative data – differences and similarities between countries

The qualitative data (open answers of the post-questionnaire, students' interviews and workshops) that were gathered by all partners gives insights in the complex and broad variety of students' subject choices and career aspirations. The most frequent reasons and main differences are summarized.

Students' further studies

Students throughout all partner countries mostly choose to attend higher secondary school. However, the reasons for that are manifold.

"I don't know what I want to be yet"
The data show that there is a high amount of students in most of the MultiCO partner countries (Finland, Germany, UK and Estonia) that have yet no idea or are quite unsure about their future. They choose attending higher secondary school to delay the decision what to do after finishing school.

"To have good job opportunities in the future"
Many other students in all partner countries who choose to attend higher secondary school wish to have a good starting point for their future career – although a lot of them don't know which career yet. These students hope for example for a broader range of possible options, the chance to study at a reputable university or to get a 'decent' career.

"I want to become a doctor and that's only possible if I finish higher secondary school"

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Furthermore there are several students in the partner countries (especially UCL, UCY and UBO) who seem to be very clear about their future careers and attend to higher secondary school to be able to obtain the place at a university in the field of their career aspiration or to work in the field they hope for.

Only few students in all partner countries plan to attend to a vocational/technical school. However, particularly these students seem to know quite well what they want to do in their future. The choice for a vocational/technical school seems to be strongly related to a specific career goal or a concrete area they want to study in the future. Some students from Cyprus and Germany mention that they attend to higher secondary school because they appreciate to learn more and to extend their skills and knowledge.

Subject choices

The reasons for students' subject choices are manifold but show a clear tendency to those subjects that the students consider as useful for their future career (even if they don't know exactly what they want to do in the future). Moreover a lot of students mentioned interest in the subject as important reason for their choice, and especially students from U.K. and Germany mentioned that they chose those subjects in which they had good grades. Interestingly only few students (especially UEF) mentioned influence factors which are directly linked to the quality of the students' science lessons (e.g. positive experiences, good teacher) – however those aspects may be part of the reason 'interest in the subject'. Therefore, influencing factors within science lessons that lead students to choose those subjects for higher secondary school cannot be clearly detected within these datasets. To find out about such factors is a main focus within the MultiCO intervention analysis and findings.

Career aspirations

A majority of the students in the 9th grade in all partner countries are still unsure about their career aspirations. In particular, some of the English students mentioned within the interviews that no one had spoken to them about potential careers and that the schools did not support them with their career planning. Indeed most of the students have at least an idea of the area they want to work in later (e.g. in the pedagogical, technical or artistic area). However, in particular the medical area seems to be an attractive field of work for students (especially UCL, UCY and UBO) which is mentioned outstandingly often by them.

Students in the U.K. and Cyprus mention more frequently that their career aspirations are related to family members like siblings which are currently involved in science jobs. In the U.K., students especially aspired to science careers which would have a positive impact on environmental challenges, like global warming. In Cyprus, students aspire to pursue a career related to their interests and self-efficacy (e.g. "*something I am good at*"). In Finland, interest, motivation, hobbies and goals in life were the most important factors. Students from all partner countries mention that good salary, a safe job, to have an interesting job and a job where they are able to help people are the main reasons for their career aspirations.

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Overall discussion and recommendations

The qualitative and quantitative data of the post-questionnaire section, the workshops and interviews allow for different perspectives on the complex reasons of students subject choices, future studies and career aspirations. The data revealed that the majority of the students participated in this task will continue their studies in a high school rather than the vocational or other types of school. Considering students' subject choices, biology was the most popular in the case of Finland and Germany. Nevertheless, in the case of Estonia and Cyprus students' most popular subject choice was advanced mathematics. Physics was the second most popular choice in Finland, Cyprus and Estonia whereas in Germany was chemistry. Geography was the least popular subject choice in all the countries except Germany. Further, some differences were found with respect to some subject choices between boys and girls. In particular, it was found that boys in Germany were more likely to choose physics than girls. On the other hand, in Finland, girls were found to be more likely to choose physics whereas boys preferred biology and geography. It is important to note though that these data cannot be generalised due to the small and not representative sample.

Overall, it should be mentioned that students at the end of the 9th grade still seem to be unsure about their future – at least concerning concrete career aspirations. However, they seem to be very sure about the wider professional fields they perceive as attractive for their future. These aspirations seem to be mostly guided by students' interest but also by rather 'functional' aspects like good salary.

Therefore, we can conclude that the MultiCO project targets in the right direction by fostering students interest development and career awareness. The outcomes of inquiries do not reveal why students perceive their chosen subjects as interesting (might be due to their teachers, practical work within the lessons etc.). Nevertheless, the outcomes of the MultiCO intervention studies hint at how to support students' interest and their career awareness in science lessons. Therefore, it would be useful to continue these efforts and motivate more schools and teachers to consider the project's outcomes to support student's interest in science and science careers.

Moreover, the project's aim to support students' awareness and realistic estimation of (science) careers is of high importance considering that they seem to look for safe jobs, a good salary and similar aspects. Students should get the opportunity to get a realistic view of different careers to take the right decision for their future – no matter if that leads them into a career in science or in another field of work.

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7. Recommendations

Overview of the project activities

MultiCO project aimed at engaging students' intrinsic motivation and promoting interest towards science study and science-related career choices through offering pre- and in-service teachers, teacher educators and policy makers, research-based evidence of the impact of innovative, context-oriented, science-related, career-based scenarios, which are used as starting points for topics taught within science teaching.

The Conceptual Framework identified four broad strands that might be addressed across the phases of the project namely: Motivation, interest, attitudes, Activities for promoting STEM careers, Counselling for STEM careers, and Subject and career choice. According to the articles reviewed, the best ways to improve interest, motivation or attitudes toward science and technology 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.)

Within the project, taking into account these factors as well as stakeholders' perceptions, partners created, piloted and developed a collection of theoretically constructed, culturally focused and practically evaluated, scenarios to act as examples for further development of career-based scenarios. Scenarios were evaluated and integrated in the instruction to be introductory part to inquiry-based learning and students' perceptions of scenarios were examined. Students' interest in science was examined before and after the period consisting of five scenario-based interventions. Available deliverables are related to activities shown in figure 18.

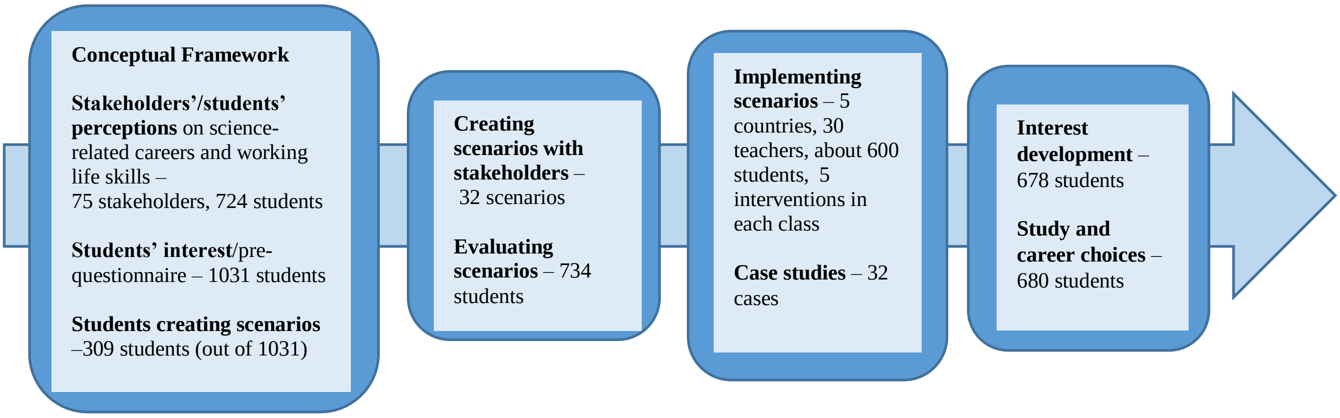

Figure 18. Key activities and participants

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A significant strand of the project was also the development of guidelines for policy and teacher education building on findings from the different phases of the study and ongoing collaboration and dialogue with participants and other stakeholders. The study aimed to mainstream good practices in using career-based scenarios.

Recommendations to science teachers

The intervention studies undertaken within the partnership show how scenarios can be selected and incorporated into science lessons to bring about student interest and motivation. From data collected from each intervention research teams have analysed the findings taking into account multiple factors. Based on this, common features, which are recommended in career-based, scenario selection and implementation, are:

- A scenario needs to be short enough so that it can fit into lesson structures and sequences to allow for links to curriculum content and science inquiry.
- The scenario needs to be well structured, clearly linking content and careers (also future careers).
- The context needs to relate to students: often this means involving people who are young as role models, involving local contexts and using examples that make reference to students' everyday culture in the modern world.
- It is preferable that scenario-based career discussions continue within or after the inquiry stages. Though scenarios are intended to be the initial motivating trigger, their impact on learning needs to be consolidated by reference to them during the lesson, or sequence of lessons.
- Scenarios can raise career awareness and are more likely to have an impact on this if they include several careers rather than only one.
- Where possible, it is advantageous to include students' own ideas and activities related to careers by involving them in scenario development.
- A common finding among partners is that scenarios which include visits (out of school), and/or include assignments for students, are particularly stimulating.
- When out of school visits take place, it is important that students are able to relate to the experts they meet so as to optimise identification of the expert's role. The experts need to be able to work with young people.
- Scenarios need to include discussion about values (for example social, ecological and economic sustainability), making science studies more relevant to students.

In creating a model for scenario development and implementation, the partnership took into account authentic and real/life socio-scientific issues, set in local contexts that address global challenges and include science-related careers. These aspects feed into the processes of introducing a potentially student-relevant concern, introducing science-related careers, linking these to science inquiry learning and, where possible, out of school visits. These processes need to take into account the curriculum expectations and teachers' confidence in handling career-based scenarios in their lessons, plus their willingness to manage out of school visits. Teachers also need to have awareness of the features that students find engaging, including appropriate careers that are accessible to students of varying academic achievement, and career roles with which students can identify. Also recommended is the integration of relevant working life occupational skills within scenario implementation, as how students perceive achievement of such skills to be important in science-related careers is more likely to lead to aspirations regarding those careers. Thus, a good scenario includes an issue to be resolved in a context, an introduction to careers and leads to an inquiry setting and consolidation to further promote curriculum competences.

The findings from partners' interventions were used to capture what could be seen as 'good practice' in using career-based scenarios. Good practice was taken to be that which motivated students to study, raised their awareness of careers, and also enabled teachers to gain satisfaction with their pedagogic practice towards achieving their objectives. Also, as partners recognised that teachers should be able to modify a given scenario according to students' needs and interest, good practice involved students appreciating the scenario as relevant and interesting. Features of good practice were emphasised across the partnership in ways that were exemplified in the following country reports. As partners had different contexts and time spans for incorporating scenarios within interventions, these interventions differ in structure. However, such differences afford rich insights into the possibilities of using career-based scenarios in science teaching and learning.

In conclusion, the countries exemplified 'good practice' in very similar ways, but there were some differences in terms of how practice was implemented and thus in how good practice emerged. Findings show that to enable students to gain authentic and realistic impressions of workplaces, people and tasks in science careers, one possibility is to give them the chance to discover those in the real world outside the classrooms. In this connection, it is advisable to choose

- those careers and workplaces with which students are not familiar, i.e. not connected to a stereotypical image of a scientist (e.g. rather a male profession, a 'lone wolf's' work) and

- workplaces which can be reached easily from schools. This aspect has the advantage that, by visiting such an out-of-school setting, the students get insights into their surrounding area and explore the importance of these workplaces for themselves, their city or society in general – what may lead to an even higher connection to a professional field in science. Another important aspect is the close cooperation with the experts at these workplaces – not only during the planning phase, but also during the intervention itself (the teacher stepping back and being a part of the learning group).

Good career-based scenarios include need, at least a topic that is of concern (a socio-scientific issue or problem) and a career setting, both leading to a scientific inquiry activity and followed up by consolidation of the intended learning, geared to the concern, the science learning and the science-related career(s).

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Recommendations to policy-makers and curriculum planners

Generally, stakeholders agreed that career awareness should be increased. This view was also supported by the literature review that showed a lack of counselling. Knowledge of science-related careers and working life skills needs to be raised in order to enable students to make relevant science study and career choices. Further, students' interest raised slightly during the five interventions although differently in different countries. The curriculum should

- give greater recognition to young people's capabilities to engage with processes associated with science-related careers, working life skills, and working with stakeholders
- include considerations of science-related careers and related working life skills linking science content in real-life/authentic context
- give time for the development of knowledge and skills to promote students' self-efficacy

Self-efficacy is important for choosing challenging studies and careers. MultiCO project advanced the right direction by fostering students' interest development and career awareness. The outcomes of the inquiries do not reveal why students perceive their chosen subjects as interesting. Nevertheless, the outcomes of the MultiCO intervention studies hint at how to support students' interest and their career awareness in science lessons. Therefore, it would be useful to continue these efforts and

- support schools and teachers to implement career-based scenarios to support student's interest in science and science-related careers.

Moreover, the project's aim to support students' awareness and realistic evaluation of (science) careers is of high importance considering that they seem to look for safe jobs, a good salary etc. It is recommended that

- students get the opportunity to acquire a realistic view of different careers to take the right decisions for their future – no matter if that leads them into a career in science or in another field of work
- national school science curriculum contains the consideration of science-related careers and related working life skills.

In science education, the collaboration with stakeholders (other community members) could be promoted by strengthening networking. It is recommended that

- to support schools in networking with stakeholders through planning schedules which allow time for collaboration as well as for creating scenarios with stakeholders and to implement integrative teaching.

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Recommendations to teacher education

Teachers in the interventions undertaken within the partnership were enthusiastic to create and implement career-based scenarios, however, they had concern how the scenarios form a continuum with the following inquiries. Teachers also had little experience in collaboration with different stakeholders. It is recommended that

- science pedagogy courses in teacher education introduce to teacher students the basic ideas for creation of careers-based scenarios and the implementation of scenarios in line with curriculum
- introduction of career-based scenarios and their use is enlarged in other disciplines e.g. technology education
- teacher education offers possibilities to experiences in collaboration with different community members such as policy makers, entrepreneurs, scientist, staff in NGOs

Recommendations to science education researchers

MultiCO- project has found some evidence about the benefits of career-based scenarios. The time used for each intervention varied across the partnership and made it challenging to compare the results. It is suggested that

- the effects of interventions constituting at least eight lessons are examined,
- more schools and teachers are invited to participate in the study of effects of scenarios in raising interest,
- mixed method studies are undertaken to deepen the knowledge of quantitative studies with qualitative studies,
- longitudinal studies are undertaken from 5 graders to 11 graders,
- effects of implementation of career-based scenarios in grades 10 to 12 are studied,
- students' prior knowledge with respect to the career presented in the scenarios are taken into account as to investigate whether the implementation of the scenario raised students' awareness.

All data collected in the project is not yet fully analysed. The partners continue this work and will publish more evidence showing the variety of influences of implementation of scenarios. Studies should be continued to find out some answers why students feel that the scenarios are relevant to the society but not to them personally.

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