Integrating Sustainability Issues into Science Education through Career-Based Scenarios in the MultiCO Project

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1. Introduction

School science education is recognised as an important area of study to comprehend the increasingly scientific world in which we live and to inspire students of all ages towards careers in science. Even more importantly, science education is appreciated for developing competences for the needs of future society, such as problem-solving and innovation, as well as analytical and critical thinking, seen as necessary to empower citizens to lead personally fulfilling, socially responsible and professionally engaging lives (European Commission 2015). However, students, especially those approaching adolescence, do not find science learning relevant (Stuckey et al. 2013). Students' declining interest towards science or the pursuit of science-related careers has been repeatedly highlighted in the science education research literature. Studies have reported that this negative trend of interest and aspirations in science starts at the end of primary school and evolves during lower secondary school years (Potvin and Hasni 2014; DeWitt and Archer 2015). A science career often requires an academic degree in a science-related or Science, Technology, Engineering, and Mathematics (STEM) field; thus, study aspiration in advanced science subjects at primary or lower-secondary school affects future career options (Sheldrake 2018). In addition, a growing need for students specialized in STEM is projected in the labour market and the proportion of STEM students in higher education is not expected to be sufficient (European Commission 2004, 2009; OECD 2008, 2017). Some mixed findings on students' interest have also been found; for instance, interest may increase significantly during the lower-secondary school phases, but there were no reciprocal relationships between interest and self-concept in predicting students' science aspirations (Kang et al. 2019).

The origin of the lack of interest or motivation, particularly in secondary science education, is seen to lie in pedagogical considerations (Potvin and Hasni 2014) and in socio-cultural capital. A major development, designed to attract young people to science studies and to raise scientific literacy among future citizens, has been to approach science education as 'education through the context of science' (European Commission 2007, 2015). Research has shown that context-based approaches in science education result in improvements in attitudes towards science (Bennett et al. 2007) and may lead to enhanced interest in science-related careers (Reid and Skryabina 2002). Teaching strategies that actively engage students in the learning process, such as through scientific investigations, strengthen conceptual understanding, and also have positive effects on students' attitudes towards science (Minner et al. 2010; Potvin and Hasni 2014). The use of models in upper secondary school was associated with a high level of situational engagement (Inkinen et al. 2020). At least one project-based course during the first four semesters affected college student STEM career aspirations (Beier et al. 2019).

Most European countries have recommended that science be taught in a context relating to contemporary societal issues (European Commission 2011; PARSEL Popularity and Relevance of Science Education for Scientific Literacy; PROFILES Professional Reflection-Oriented Focus on Inquiry-Based Learning and Education through Science; Bolte et al. 2012). Context-based science education, using cross-cutting themes, also has the opportunity to connect educational aims to several EU strategic priorities such as water resource management, raw materials, energy management, information and communication technologies (ICT), nutrition, health, and climate change. The MultiCO project has contributed to these trends in science education research by studying the impact of the introduction, for secondary school students (ages 13 to 15), of real life related, career-focused stories, referred to as scenarios. Scenarios initiate context- and inquiry-based science lessons and are intended to inform students' preferences for choosing science studies and increase their desire to reflect on an increased awareness of, and the attractiveness in pursuing, science-related careers. The project carried out a series of longitudinal studies of classroom interventions using motivational scenarios. These scenarios were created with multi-stakeholder co-operation between scientists in education, natural science, and experts from industry and civil society organisations, formal, as well as non-formal science educators and students. 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 interest and career-awareness on students' science study choices, and attitudes towards science-related careers.

In a broader sense, the MultiCO project created a mechanism for attractive science education, aiming to raise the number of future scientists that will be engaged in resolving major societal challenges related to sustainability issues, as well as strengthening the capacity of scientifically literate citizens to participate more meaningfully as decision-makers and social actors. This book chapter introduces how sustainability issues related to energy, water, waste, food, health, transport and climate change are incorporated in career-based scenarios for enhancing student motivation for science studies and science-related careers.

2. Science Education and Sustainability

Sustainability is widely recognised in school curricula as an important societal priority. For example, in the Finnish core curriculum, sustainability is included in one of the seven transversal competence areas, namely 'participation, involvement and building a sustainable future' (Finnish National Board of Education 2016). These competence areas epitomise the aims of education and reflect the competences needed in life. They are enacted through 'multidisciplinary learning modules' which integrate learning and increase the dialogue between different subjects. Schools organise one such module at least every school year. The core curriculum obliges schools to plan and implement these by making connections between different subjects (e.g., biology, chemistry, physics) and involving pupils in their planning. Apart from these obligations, the municipalities and schools have the freedom to plan the modules according to local needs and interests (Finnish National Board of Education 2016).

Sustainability can be promoted through a variety of pedagogical approaches. Widely, this is realised under the concept of Education for Sustainable Development (ESD). Researchers describe ESD with different terminology. However, there is an emerging consensus that ESD, as an approach in teaching, should deal with the complexity of a globalized world. The key principles of ESD are (UNESCO Education for Sustainable Development Goals 2017; UNESCO 2009, p. 26):

- A transformative and reflective process that seeks to integrate values and perceptions of sustainability into, not only education systems, but one's everyday personal and professional life;
- A means of empowering people with new knowledge and skills to help resolve common issues that challenge global society's collective life now and in the future;
- A holistic approach to achieve economic and social justice and respect for all life;
- A means to improve the quality of basic education, to reorient existing educational programmes and to raise awareness.

Similar focus in science education is on helping students become scientifically literate citizens who can participate in socio-scientific discourse (Hofstein et al. 2011) including sustainability issues. Particularly, the Societal Science Issues (SSI) approach seeks to promote goals in science education related to general interest and public understanding with particular reference to:

- Individual empowerment;
- Intellectual capabilities such as critical thinking, logical reasoning/analytical skills, creative problem-solving and decision-making;
- National and global citizenship;
- Socially responsible action by individuals and communities;
- Communication skills in a variety of forms; and
- Providing a skilled workforce for business and industry

(Aikenhead 1994, p. 49; Aikenhead 2000, p. 53; Rannikmäe 2002; Holbrook and Rannikmäe 2007; Havu-Nuutinen and Keinonen 2009).

Many of these skills can be addressed through argumentation activities, set in SSI contexts (Baytelman et al. 2020; Iordanou and Constantinou 2014; Ekborg et al. 2012; Simon et al. 2006; Simon and Richardson 2009). These skills, activities and pedagogical approaches are similar to those highlighted in ESD (Lozano et al. 2017; Bacon et al. 2011; Tilbury 2011; Laurie et al. 2016; United Nations 2015).

The strong relationship between ESD and quality education has been recognised by many leading organisations and scholars (Laurie et al. 2016). Quality education is identified as one of the seventeen Sustainable Development Goals (SDG, Goal 4) and education is a cross-cutting issue in many of the other 17 goals adopted in UN's agenda. SDG 4 focuses on ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all. According to Laurie et al. (2016), ESD contributes to a quality education when ´the curriculum includes sustainability content—delivered in terms of local, social, economic and environmental contexts´. The definition of quality education is constantly evolving and is always contextual (Laurie et al. 2016). Quality education makes content relevant in order to prepare students to enter community life and the workforce (UNESCO 2005).

The MultiCO project outcomes contribute to ESD and the target of SDG 4 promoting students' knowledge and skills for equal access for all to affordable and quality education. Through planning relevant science education for all to motivate young people for science studies, MultiCO aimed to increase the number of youth and adults who have relevant skills for employment, decent jobs, and entrepreneurship. The project contributed methods and tools to ensure that learners acquire the knowledge and skills needed to promote sustainable development, including, among others sustainable lifestyles, gender equality, global citizenship and appreciation of cultural diversity, as well as of culture's contribution to sustainable development. The project sought to clarify how the scenarios in the context-based approach stimulate students and relate to educational gains related to working life skills and responsible citizenship.

3. Career Aspect in Science Education

Potvin and Hasni (2014) found in their review that issues positively affecting interest, motivation and attitudes were associated with: role models or science and technology careers in interventions; students' self-efficacy; authentic tasks; contact with scientists and working collaboratively. One factor associated with greater probability of uptake of physics was expected performance. In addition, the manner in which courses were taught was important to the recruitment and retention of students in the STEM disciplines (Gill and Bell 2013). Another finding was that informal programmes influence study and career choices, but these needed to be longer, for example, lasting one year (Fadigan and Hammrich 2004). Ainley and Ainley (2011) suggested that efforts to increase the attractiveness of science to students should take heed of the fact that enjoyment of science had a central role in the paths linking personal value, interest and current science activities to intentions for future participation in science.

Students need knowledge about career opportunities to be able to make informed choices. Middle grade students are not often made aware of career options, and few indicate knowing professionals actively working in STEM or the environment fields (Maltese and Tai 2011). Several authors have proposed how different factors might influence career choice. Eccles (2009) suggests that self-related beliefs regarding both one's relative competences and the relative subjective task value are critical influences on behavioural choices. Andersen and Ward (2014) suggest that students need to be made more aware of the utility of science courses in relation to their future goals for careers and study plans. van Aalderen-Smeets et al. (2018) found that there is a positive relation between implicit STEM ability beliefs and the intention to opt for a STEM field bachelor's degree. Incremental STEM ability beliefs predicted positive self-efficacy beliefs and increased STEM intention.

Students' conceptions of careers were stable through at least several years of adolescence and early adulthood (Masnick et al. 2010). Masnick et al. also found that students had a strong perception that scientific careers are not particularly creative and did not involve much interaction with others. To increase the utility value of school science, providing students with information and advice about career options and the corresponding educational requirements was seen to be critical. Mau (2003) shows that academic proficiency and mathematics self-efficacy are the two strongest predictors of persistence in science and engineering careers. Lykkegaard and Ulriksen (2019) followed students during and after their completion of upper-secondary education and noticed that only 22% of students expressed the same interest during the whole period, and 56% changed between different groups of studies, e.g., between STEM and HEALTH. Students need accurate information about STEM careers and this information needs to be part of science curricula and high school career counselling (Holmegaard et al. 2014).

In the MultiCO project, it was assumed that career awareness and inquiries have together a positive effect on science interest and motivation towards science studies and should be promoted in unison. The career aspect was implemented using career-based scenarios. Scenarios are defined as motivational student-relevant constructs, expressed in words, which might also be illustrated/expanded by cartoons, graphics, videos, and/or presentation slides, related to an attractive problem, or issue, or an unexpected or extraordinary situation, with the possibility to involve students in an unusual scientific, hands-on activity (seen as relevant by students) and include career-related aspects. The problem, issue or situation is linked to EU challenges related to energy, water, waste, climate change, food, health, or transport issues.

The scenario is interesting to students in general and hence the scenario is not gender specific. The scenario needs to be "relevant in the eyes of the students" and not as perceived by the teacher. The scenario context is thus most likely connected with:

- Students' personal lives, either now or in the future (personal relevance);
- A social problem/issue or problems/issues, which may have a (hidden) science component (social relevance);
- Updated global or local problems/issues (media relevance).

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. 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.

A scenario may include for example:

1. An industry visit. The purpose of the visit can be descriptive, or problem-oriented.
2. A virtual scenario (e.g., a video showing work in industry, or a video of a visit pointing out different aspects of a career or a person's life).
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. A problem to be solved (industry linked, science-related).

The career aspect does not necessarily need to be directly presented in all cases. It can be latent in an industrial or in any other STEM related context. In this chapter, we present some of the MultiCO scenarios and what ESD aspects these scenarios include.

4. Sustainability Included in the MultiCO Career-Based Scenarios

The aim of this chapter is to show how sustainability is included in the MultiCO scenarios. Sustainability in the scenarios is evaluated based on the following ESD aspects, as already described in detail in the previous sections:

- Content (energy, water, waste, climate change, food, health and transport issues);
- Context (local, social, economic, and environmental);
- Pedagogy (for example inquiries, group work, real-world problem solving);
- Skills (collaboration, communication, scientific reasoning, creativity, based on the MultiCO aims).

The project has published 32 scenarios, all of which are openly accessible.[1] Out of these, 27 scenarios have a significant relationship to sustainability and are presented in this chapter. The connections are shown in Tables 1–5. Because the project focused on raising scientific career awareness, the career aspect is also shown in Tables 1–5, besides the content, context, pedagogy, and skills. Other scenarios not mentioned here may also include sustainability issues depending on how a teacher chooses to implement the scenarios.

The scenarios introduce careers and sustainability aspects in a variety of ways. Next, we present some of the scenarios. For example, the scenario Chemical Design Engineer, created by the University College London team, introduces an expert, Nadina, her work and the working life skills needed in her job (Figure 1). This is one way to raise students' career awareness. Following the scenario, the students are given a task to design products that minimise sports injury: "Your latest task is to design two instant sports injury packs" (Figure 1). The sports injury problem can be interpreted to be global and social, addressing issues pertaining to health

[1] See MultiCO. Available online: www.multico-project.eu (accessed on 6 August 2019).

and wellbeing. Students are asked to take the role of an expert and use scientific information in order to formulate realistic specifications and design the products. This task calls for creativity and scientific thinking. It is expected that students work in collaboration and they need to reason in their designs.

Table 1. MultiCO scenarios and their sustainability aspects in Cyprus.

Scenario Title	Content	Career Aspect	Context/Socio-Scientific Issue	Pedagogy	Skills
Acoustics Club	Waves and Sound	Acoustic/sound engineer, Mechanical engineer, Physicist	Local, Social and Environmental/ *Club for teenagers, Noise*/ Health	Real world problem solving	Collaboration, Creativity, Reasoning
Fly if you can	Motion Newton's, laws	Aeronautical & aircraft engineer, Mechanical & electrical engineer	Global, Economic, Environmental/ *Emergency landing problems*/ Climate Change, Transport	Design, Competition, Group work	Creativity, Collaboration
Nuclear Decisions	Sustainable development	Geologist, Environmentalist, Hydrologist, Seismologist, Meteorologist	Global, Economic, Environmental/ *Location of the nuclear plant, Environment Protection*/ Energy	Problem solving	Communication, Collaboration
Save the polar bears!	Heat transfer, Conductors Insulation	Architects specialized in energy-efficient buildings	Global, Social, Economic, Environmental/ *Energy Efficiency*/ Climate Change, Energy	Role play, Design	Reasoning, Creativity
Two wheeled mission	Speed and motion	Civil engineer	Local, Social, Economic, Environmental/ *Car emissions, Traffic congestion*/ Climate Change, Traffic	Problem solving, Video	Reasoning, Decision making, Collaboration
Zero plastics to landfill by 2020	Pure and impure substances, Process of combustion Sink and float	Environmental scientist	Global, Social, Economic, Environmental/ *Plastic waste, Recycling*/ Waste	Cartoon, Investigations	Collaboration

Table 2. MultiCO scenarios and their sustainability aspects in Estonia.

Scenario Title	Content	Career Aspect	Context/Socio-Scientific Issue	Pedagogy	Skills
Electricity in the air	Electricity, particles	Engineer, Material Scientist, Environmental Protection Specialist	Global (Local), Social, Economic, Environmental/ *Energy consumption and production, Solar power*/ Energy, Climate change	Design, Role play	Creativity, Collaboration, Reasoning
Endangered species	Ecology, poisoning substances	Customs officer, Environmentalist, Natural scientist, Specialists of tourism and finances	Global, Social, Economic, Environmental/ *International trade, Environmental protection, Ethics and social responsibility*/ Climate change, Transport	Role play, Group work	Collaboration, Communication, Reasoning
Oil - the king of the world or Achilles heel?	Heating value, oil properties and composition	Chemist, environmental expert, journalists, zoologist	Global, Social/ *Environmental protection*/ Climate change, Transport	Investigations	Collaboration
Should there be a sugar tax?	Titration, Substance identification, pH	Technologist, chemist, bio-chemist	Global, Social, Economic/ *Sugar tax*/ Health	Debate, Visit, Interview	Reasoning, Collaboration, Creativity

Table 3. MultiCO scenarios and their sustainability aspects in U.K.

Scenario Title	Content	Career Aspect	Context/Socio-Scientif Issue	Pedagogy	Skills
Chemical design engineer	Energy in reactions	Chemical Design Engineer	Global, Social/*Cold pack planning, Sport injuries, Injuries*/Health	Role play, Design	Creativity, Collaboration, Reasoning
Lamb, lime and mussels	Neutralisation	Sheep farmer, Aqua culturist, Agronomist	Local, Social, Environmental/ *Waste management*/Climate change, Food	Role play, investigations	Communication
Nuclear medicine	Nuclear radiation	Nuclear Medicine Technologist	Global, Social/ *Radioactive substances/Health*	Role play, Investigations	Communication, Reasoning
Roundabout	Sustainable energy	Traffic Engineer	Local, Social/ Environmental/ *Participation in Society, Traffic congestion/* Climate change, Traffic	Surveys, Participation	Collaboration, Reasoning

Table 4. MultiCO scenarios and their sustainability aspects in Finland.

Scenario Title	Content	Career Aspect	Context/Socio-Scientific Issue	Pedagogy	Skills
Blackout	Generator, Transformer, Electric grid	Electrician, forester, staff manager, purchasing manager, production manager, customer service, process operator, power network designer	Local (Global), Social, Environmental/ *Blackout, Electric grid/* Energy	Group work, Play	Collaboration, Reasoning
Car park	Velocity	Project engineer	Local, Social, Environmental/ *City and traffic planning, Noise and air pollution/* Climate change, Transport	Visit in construction site	Collaboration, Reasoning
Coal to the teeth	Activated carbon, Acid erosion (pH)	Dentist, chemist	Local (Global), Social/*Teeth whitening*/Health	Real world problem solving, Collaboration with dentist	Collaboration, Reasoning, Communication
Life cycle	Product's life cycle	Experts chosen by the students related to the product	Local, Social, Economic, Environmental/ *Life cycle*/Waste, Energy, Water, Climate Change	Video (Youtube), Interview	Reasoning, Communication
Old pipes found	Thermal expansion	NC-machinist, calibrator	Local/*Recycling*/Waste	Visit, Investigations	Collaboration, Communication, Reasoning
Pedestrian crossing	Velocity	Municipal engineering	Local/ *Participation in Society*/Safety, Transport	Investigations, Participation	Collaboration, Reasoning
Recruitment fair	Electrolysis	Prototype producer, machinist CNC-machinist, laboratorian, task organizer	Local/ *Working life*/Safety	Visit, Role play	Reasoning
Sport physician	Thermal equilibrium	Sport physician, Doctor	Global, Social/ *Heat problems/* Health	Mind map	Reasoning, Collaboration
Water purification	Soluble-insoluble, Separation methods	Chemist, municipal engineer	Local, Environmental/*Water supply/* Climate change, Water	Problem solving, Meeting a chemist	Creativity, Collaboration, Reasoning

Table 5. MultiCO scenarios and their sustainability aspects in Germany.

Scenario Title	Content	Career Aspect	Context/Socio-Scientif Issue	Pedagogy	Skills
Crime scene	Electricity, electric shock, safety at home	Electrician, Horticulturist, Forensic chemist, Zoologist, Pharmacist	Local, Social/ *Safety*/ Health	Problem solving	Reasoning
Road salt	Salts	Chemist, CEO in industry, Sales Manager industrial, Chemical technician	Local, Social, Environmental/ *Ice problems*/ Climate change, Traffic	Investigations, Group work	Creativity, Collaboration, Reasoning
Forester	Ecology	Forester, Forest engineer	Local, Environmental, Economic/ *Forest use vs. Forest protection*/ Climate change	Investigations, Group work	Creativity, Communication, Collaboration, Reasoning
Giant dinosaurs	Evolution	Paleontologist, Biologist	Environmental, Global/ *Human impact on our world*/ Climate change	Group work, Discussion	Communication, Scientific reasoning, Creativity

Figure 1. Chemical Design Engineer scenario. Introduction of the professional and task for the students. Source: www.multico-project.eu. Used with permission.

Overall, students were very enthusiastic with the practical activity presented in the scenario. However, half the students reported that it did not make them want to learn more about the topic, mainly due to their lack of interest in the topic. The students who expressed a wish to learn more about it, mentioned their future career and interest. Around two thirds of the students said the scenario was enjoyable and liked its format.

In another scenario, Blackout, created by the University of Eastern Finland team, students are given cards with names of electrical devices. Later they ponder what could happen in a situation where there is no electricity. At the end of the scenario, students are familiarized with one career in the field of electricity production and distribution and design a job advertisement for that career (Figure 2). The electricity context is local or global, social, and environmental. Students are instructed to work in groups and a role-playing game has been created to support learning. Students practice collaboration and evidence-based reasoning.

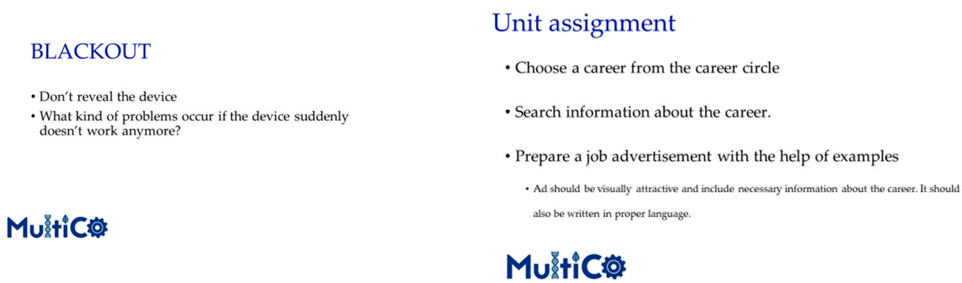

Figure 2. Two slides of the Blackout scenario. The slides show two of the tasks assigned to students. Source: www.multico-project.eu. Used with permission.

The students were interested in the concepts and problems around the electricity production and distribution. The students liked the visit outside of school and learning together. In contrast, they perceived that the writing and reporting were not that interesting. However, most of the students appreciated the newly acquired knowledge about multiple careers.

The scenario Endangered Species created by the University of Tartu team includes, for example, the slides about activity IV and V (Figure 3). Students become familiar with endangered species and also with customs and environmental service careers. The scenario considers a global issue (International Trade) with social, economic, and environmental aspects. It offers possibilities for discussion about ethics, social responsibility, and climate change. The pedagogy includes role play and group work, thus promoting collaboration, communication, and evidence-based reasoning. This module was interesting and enjoyable for students and student feedback was very positive.

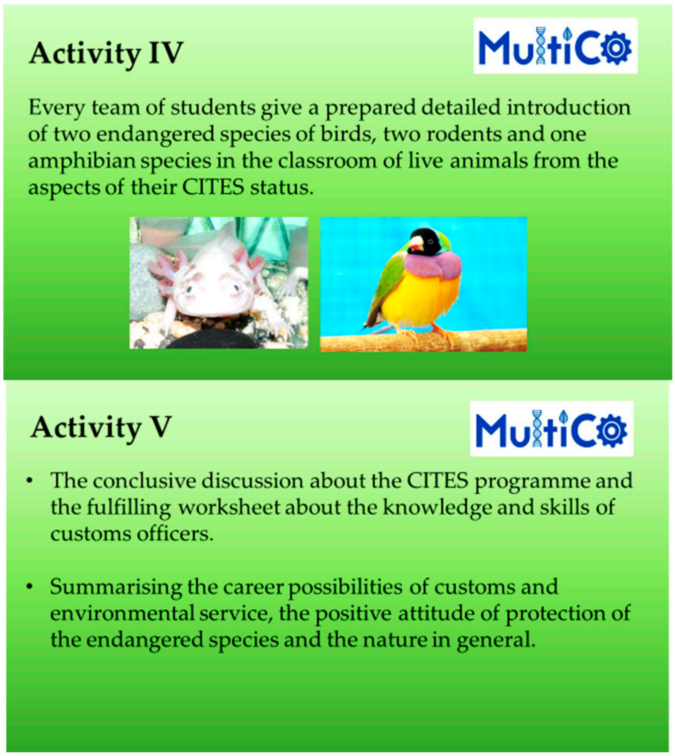

Figure 3. Two slides from the Endangered Species scenario. Source: www.multico-project.eu. Used with permission.

The scenario Road Salt created by the University of Bonn team presents students with mail communication that the Mayor has received (Figure 4). Based on these messages, students need to test an alternative product for road salt and, in the process, develop familiarity with careers related to the production of an alternative product. The issue is local, social, and environmental. It is related to climate change. Students make investigations in groups as experts and practise creativity and collaboration, and particularly scientific reasoning when communicating their results.

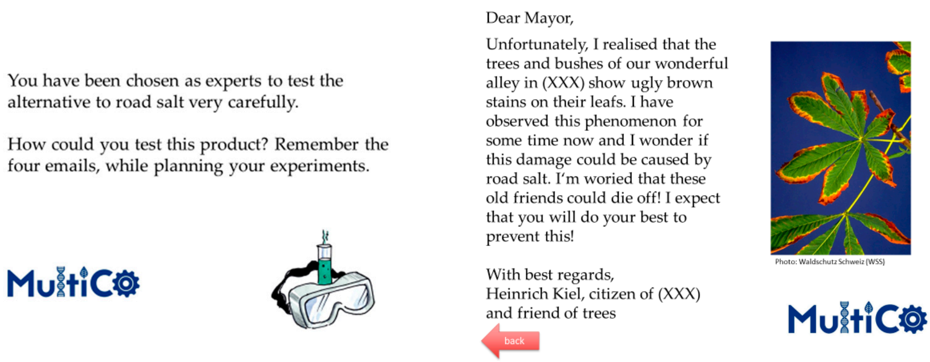

Figure 4. The scenario Road Salt introduced problems caused by road salt and invited students to test an alternative, make a decision about its suitability and present their results to the Mayor. Source: www.multico-project.eu. Used with permission.

The students perceived the topic as important for society. According to their reports, the scenario enabled them to understand the skills that are necessary in this profession. The scenario was easy to understand and it was fun to engage with. The students liked the format of the scenario.

The Zero Plastics scenario created by the University of Cyprus team considers the issue of waste generation and management. The cartoon guides students to the problem area and through the engineer's presentation the scenario introduces the task for the students (Figure 5). The issue is global, social, economic, as well as environmental. Cartoons created by the students are used to elaborate and represent the issue. Afterwards, students undertake investigations in collaborative groups.

5. Discussion

The EU Horizon 2020 MultiCO project focused on creating career-based scenarios as teaching-learning tools for making science education more relevant to students. In this chapter, we have introduced these scenarios in the light of sustainability. Through scenarios it was aimed to develop attractive science education and raise the students' interest in science as well as their awareness of science-related careers. Through these approaches, it is possible to influence the number of future scientists that would be in a position to engage in solving major challenges such as those related to energy, water, waste, climate change, food, health, and transport issues. All the created scenarios are related to these fields of science. Many of the scenarios are explicitly related to one or more topics associated with these domains. All of them can be connected to a sustainability issue even in those cases where that it is not

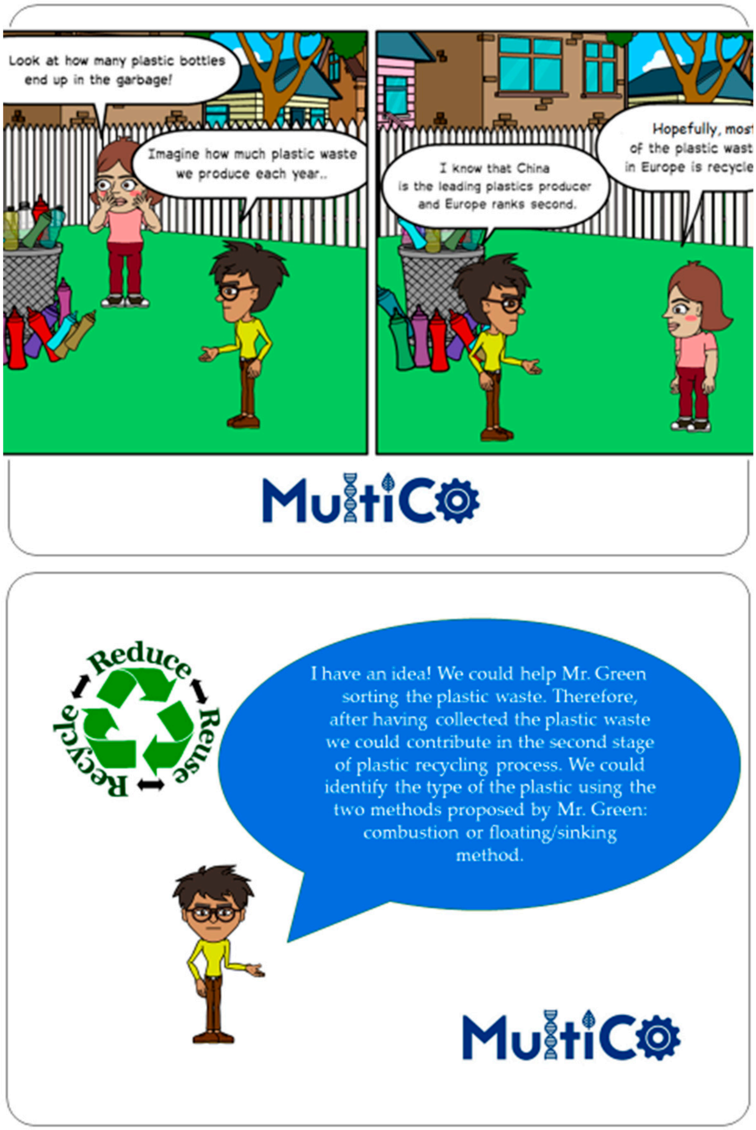

Figure 5. Slides from the Zero Plastics scenario. One innovative feature in this scenario are the cartoons created by the students. Source: www.multico-project.eu. Used with permission.

clearly stated in the scenario. The project also aimed to strengthen the capacity of scientifically literate citizens to undertake initiative as decision-makers and social actors and thus in many of the scenarios decision-making and social participation is practiced through the supported activities. The project's career-based scenarios have always taken an approach that promotes 'education through the context of science' (European Commission 2007, 2015), they may result in improvements in attitudes towards science (cf. Bennett et al. 2007; Minner et al. 2010; Potvin and Hasni 2014) and they have been designed for nurturing a higher interest in science-related careers (cf. Reid and Skryabina 2002). Students' interest was measured after implementing five scenarios in school classrooms and it seems that the career-based scenarios as a pedagogical approach offer appropriate interventions for raising interest in science (see D5.1 and D5.2 reports, www.multico-project.eu). During the 2.5 years of the MultiCO project duration, student interest in science, after studying with five scenarios, increased significantly (D5.1). Investigating the different aspects of interest, a significant increase could be revealed for all subcomponents. However, the changes in the emotional aspect, the value aspect and knowledge aspect regarding health topics were characterized by small effect sizes, whereas the knowledge aspect regarding technology and sustainability topics showed a negligible effect size. Scenarios had strong connections with sustainability aspects, but this did not increase students' interest in sustainability topics.

Students' perceptions of scenarios were investigated with case studies involving detailed lesson observations, collection of teaching-learning artefacts as well as teacher and student interviews. Through these studies we found that, for example, after the 'Water purification' scenario, students perceived that they acquired knowledge about science, science-related careers and working life skills and they reported that they enjoyed studying chemistry and were fully engaged in learning during the intervention (Salonen et al. 2018). The students appreciated the need for professionals and their responsibilities as well as the importance of water-related issues as global and local problems, but the issue was not personally important or valuable for students. Using Life Cycle Analysis (LCA, 'Life cycle Scenario') as a context, brings individual, societal, and vocational relevance to science education (Tolppanen et al. 2019). The study shows that LCA offers the opportunity for students to see science in a real-life context and promotes discussion on ethical and moral issues, which are needed much more in science education that is standard in conventional educational practices. Students understand the importance of LCA to their life and especially to society.

Career-based scenarios significantly raised students' awareness of career options, and introduced professionals actively working in science related fields (cf. Maltese and Tai 2011). The MultiCO scenarios consider scientific and technological developments within society, and, through scenarios, students are familiarized with research organisations and industry, as well as respective scientific careers.

MultiCO scenarios also connect educational aims to the several EU strategic priorities such as water, raw materials, energy, health, and the greenhouse effect. They contribute to promoting sustainability education even though interest in science did not increase in regard to sustainability. The scenarios aim to raise general interest and particularly enhance scientific reasoning, creative problem-solving and decision-making, local and global citizenship, socially responsible action by individuals, communication skills in a variety of forms, providing skilled young people for the next education level and later workforce for business and industry (Aikenhead 2000; Rannikmäe 2002; Holbrook and Rannikmäe 2007; Lozano et al. 2017; Bacon et al. 2011; Tilbury 2011; Laurie et al. 2016; UNESCO 2005). All the MultiCO scenarios promote collaborative group work, most of them can be used to teach evidence-based reasoning and communication and many scenarios provide opportunities for practising creativity (in designing and carrying out the inquiries) (cf. Lozano et al. 2017; Bacon et al. 2011; Tilbury 2011; Laurie et al. 2016; UNESCO 2005). These competences are taken into consideration in the evaluation of scenarios and also in the student assessment. However, the skills development is not limited to these competences. Many other skills are promoted at the same time: critical thinking, community participation, responsibility, to mention a few. Similar skills are also pointed out in sustainability education. Working life skills are promoted in all the scenarios in multifaceted ways.

In relation to ESD, MultiCO scenarios are designed to incorporate both affective and cognitive aspects of learning (cf. Laurie et al. 2016) using contexts relevant to students. The scenarios include decision-making through social learning (Wals 2011) and empower students to take action on issues related to sustainability (Mogensen and Schnack 2010). Local or global perspectives are included in the scenarios (Laurie et al. 2016). Critical thinking and analysis are also highlighted in unison (Lozano et al. 2017; Bacon et al. 2011; Tilbury 2011; Laurie et al. 2016; UNESCO 2005).

The career-based scenario approach promotes quality education, as teaching includes a sustainability content, delivered mainly in terms of local, social, and environmental contexts (Laurie et al. 2016). When the scenario is related to health issues, it also promotes healthy lives and well-being, some promote sustainable consumption and production patterns and some support taking actions to combat climate change and its impacts. Career awareness has been raised which may change conceptions of scientific careers (Masnick et al. 2010) and lead to study choices and choosing scientific careers (Maltese and Tai 2011). Career-based scenarios are planned to be part of science curricula as Holmegaard et al. (2014) have suggested.

As MultiCO scenarios include a combination of role models, science and technology careers in interventions, authentic tasks, contact with scientists and working collaboratively, it is reasonable that they affect positively interest, motivation, and attitudes (Potvin and Hasni 2014). The MultiCO interventions have had in some cases an effect on teachers and school culture (Salonen et al. 2018). Students mostly enjoyed studying science through scenarios which leads to enhanced interest and to intentions for future participation in science.

The MultiCO project is implemented in the Western countries; thus, the discussion about quality education may be limited to these educational contexts. However, the scenarios have also been presented to a group of Namibian teacher students and teachers, who were asked to create career-based scenarios for their purposes in Namibian science education. In discussions afterwards, the teacher students and teachers perceived the career-based scenario approach to be relevant also in the Namibian context. We may assume that the approach is also suitable and has the potential to promote quality education in developing country contexts.

6. Conclusions

The aim of this chapter was to introduce MultiCO career-based scenarios from the perspective of addressing sustainability. The MultiCO project's career-based scenarios focus on sustainability issues related to energy, water, waste, climate change, food, health and transport, on career awareness, on skills associated with a multitude of scientific careers and particularly on promoting collaboration, creativity and evidence-based reasoning. The aims of the MultiCO project realized through the career-based scenarios are in line with the aims of ESD and quality education. Thus, MultiCO scenarios can be used as a part of ESD in efforts to promote sustainability.

The project focused on promoting career awareness and on raising interest in science using different contexts for scenarios. Sustainability issues were included in most of the scenarios and the rest could all be used in connection with topics relating to sustainability. Scenario-based teaching increased students' interest in science in regard to sustainability issues and particularly in regard to health issues. Students enjoyed studying with scenarios and their career awareness was significantly enriched. The relevance of scenarios was seen by students and teachers to be more societal than individual.

Science and career aspirations were examined post-hoc, after implementations of five scenarios. The majority of participating students will continue their studies in a high school rather than 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 it was chemistry. Geography was the least popular subject choice in all these countries except Germany. 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, such as good salary, higher employment prospects and good job security. Therefore, we can conclude that the MultiCO project targets in the right direction by fostering students interest development and career awareness.

The scenarios are published and are openly accessible on the project website. Scenarios are created to fit the needs of particular curricula and local expectations. Some of the scenarios were adapted and enacted in other partner countries and, as a result, they exist in two versions with interesting differences that relate to educational context.

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References

Aikenhead, Glen. 1994. What is STS Science Teaching? In *STS Education*. Edited by Joan Solomon and Glen. S. Aikenhead. New York: Teachers College Press, pp. 47–59.

Aikenhead, Glen. 2000. STS Science in Canada. From Policy to Student Evaluation. In *Science, Technology, and Society. A Sourcebook on Research and Practise*. Edited by David. D. Kumar and Daryl. E. Chubin. New York: Kluwer Academic, pp. 49–89.

Ainley, Mary, and John Ainley. 2011. A Cultural Perspective on the Structure of Student Interest in Science. *International Journal of Science Education* 33: 51–71. [CrossRef]

Andersen, L., and T. J. Ward. 2014. Expectancy-Value Models for the STEM Persistence Plans of Ninth-Grade, High-Ability Students: A Comparison Between Black, Hispanic, and White Students. *Science Education* 98: 216–42. [CrossRef]

Bacon, C. M., D. Mulvaney, T. B. Ball, E.M. DuPuis, S.R. Gliessman, R.D. Lipschutz, and A. Shakouri. 2011. The creation of an integrated sustainability curriculum and student praxis projects. *International Journal of Sustainability in Higher Education* 12: 193–208. [CrossRef]

Baytelman, A., K. Iordanou, and C. P. Constantinou. 2020. Epistemic beliefs and prior knowledge as predictors of the construction of different types of arguments on socioscientific issues. *Journal of Research in Science Teaching*, 1–29. [CrossRef]

Beier, M. E., M.H. Kim, A. Saterbak, V. Leautaud, S. Bishnoi, and J.M. Gilberto. 2019. The effect of authentic project-based learning on attitudes and career aspirations in STEM. *Journal of Research in Science Teaching* 56: 3–23. [CrossRef]

Bennett, J., F. Lubben, and S. Hogarth. 2007. Bringing Science to Life: A Synthesis of the Research Evidence on the Effects of Context-Based and STS Approaches to Science Teaching. *Science Education* 91: 347–70. [CrossRef]

Bolte, C., J. Holbrook, and F. Rauch. 2012. *Inquiry-based Science Education in Europe: First Examples and Reflections from the PROFILES Project*. Graz: University of Klagenfurt.

DeWitt, J., and L. Archer. 2015. Who Aspires to a Science Career? A comparison of survey responses from primary and secondary school students. *International Journal of Science Education* 37: 2170–2192. [CrossRef]

Eccles, J. 2009. Who Am I and What Am I Going to Do with My life? Personal and Collective Identities as Motivators of Action. *Educational Psychologist* 44: 78–89. [CrossRef]

Ekborg, M., C. Ottander, E. Silfver, and S. Simon. 2012. Teachers' experience of working with socio-scientific issues: A large scale and in depth study. *Research in Science Education* 43. [CrossRef]

European Commission. 2004. *Europe needs more scientists. Report of the High Level Group on Human Resources for Science and Technology in Europe*. Ispra: European Commission.

European Commission. 2007. *Science Education Now: A renewed pedagogy for the future of Europe*. Ispra: European Commission.

European Commission. 2009. *Challenging Futures of Science in Society. Emerging Trends and Cutting-Edge Issues*. The Masis Report. Ispra: European Commission.

European Commission. 2011. *Science Education in Europe: National Policies*. Practices and Research. Ispra: European Commission.

European Commission. 2015. *Science Education for Responsible Citizenship*. Ispra: European Commission.

Fadigan, K.A., and P.L. Hammrich. 2004. A Longitudinal Study of the Educational and Career Trajectories of Female Participants of an Urban Informal Science Education Program. *Journal of Research in Science Teaching* 41: 835–60. [CrossRef]

Finnish National Board of Education. 2016. New National Core. FNBE/2016. Available online: https://www.oph.fi/sites/default/files/documents/new-national-core-curriculum-for-basic-education.pdf (accessed on 14 July 2020).

Gill, T., and J.F. Bell. 2013. What Factors Determine the Uptake of A-level Physics? *International Journal of Science Education* 35: 753–72. [CrossRef]

Havu-Nuutinen, S., and T. Keinonen. 2009. Learning Electricity through STS-Learning Environment. *The International Journal of Learning* 16: 177–87. [CrossRef]

Hofstein, A., I. Eilks, and R. Bybee. 2011. Societal issues and their importance for contemporary science education: A pedagogical justification and the state of the art in Israel, Germany and the USA. *International Journal of Science and Mathematics Education* 9: 1459–83. [CrossRef]

Holbrook, J., and M. Rannikmäe. 2007. Nature of Science Education for Enhancing Scientific Literacy. *International Journal of Science Education* 29: 1347–62. [CrossRef]

Holmegaard, H.T., L.M. Madsen, and L. Ulriksen. 2014. To Choose or Not to Choose Science: Constructions of desirable identities among young people considering a STEM higher education programme. *International Journal of Science Education* 36: 186–215. [CrossRef]

Inkinen, J., C. Klager, K. Juuti, B. Schneider, K. Salmela-Aro, J. Krajcik, and J. Lavonen. 2020. High school students' situational engagement associated with scientific practices in designed science learning situations. *Science Education* 104: 667–692. [CrossRef]

Iordanou, K., and C.P. Constantinou. 2014. Developing pre-service teachers' evidence-based argumentation skills on socio-scientific issues. *Learning and Instruction* 34: 42–57. [CrossRef]

Kang, J., T. Keinonen, and A. Salonen. 2019. Role of Interest and Self-Concept in Predicting Science Aspirations: Gender Study. *Research in Science Education*. [CrossRef]

Laurie, R., Y. Nonoyama.Tarumi, R. McKeown, and C. Hopkins. 2016. Contributions of Education for Sustainable Development (ESD) to Quality Education: A Synthesis of Research. *Journal of Education for Sustainable Development* 10: 226–42. [CrossRef]

Lozano, R., M.Y. Merrill, K. Sammalisto, K. Ceulemans, and F.J. Lozano. 2017. Connecting Competences and Pedagogical Approaches for Sustainable Development in Higher Education: A Literature Review and Framework Proposal. *Sustainability* 9: 1889. [CrossRef]

Lykkegaard, E., and L. Ulriksen. 2019. In and out of the STEM pipeline—A longitudinal study of a misleading metaphor. *International Journal of Science Education* 41: 1600–25. [CrossRef]

Maltese, A.V., and R.H. Tai. 2011. Pipeline Persistence: Examining the Association of Educational Experiences with Earned Degrees in STEM Among U.S. Students. *Science Education* 95: 877–907. [CrossRef]

Masnick, A.M., S. Stavros Valenti, B.D. Cox, and C.J. Osman. 2010. A Multidimensional Scaling Analysis of Students' Attitudes about Science Careers. *International Journal of Science Education* 32: 653–67. [CrossRef]

Mau, W-C. 2003. Factors That Influence Persistence in Science and Engineering Career Aspirations. *The Career Development Quaterly* 51: 234–43. [CrossRef]

Minner, D.D., A.J. Levy, and J. Century. 2010. Inquiry-Based Science Instruction- What Is It and It Matter? Results from a Research Synthesis Years 1984 to 2002. *Journal of Research in Science Teaching* 47: 474–96. [CrossRef]

Mogensen, F., and K. Schnack. 2010. The Action Competence Approach and the 'New' Discourses of Education for Sustainable Development, Competence and Quality Criteria. *Environmental Education Research* 16: 59–74. [CrossRef]

OECD. 2008. *Education at a Glance*. Paris: OECD.

OECD. 2017. *In-Depth Analysis of the Labour Market Relevance and Outcomes of Higher Education Systems: Analytical Framework and Country Practices Report*, *Enhancing Higher Education System Performance*. Paris: OECD.

PARSEL (Popularity and Relevance of Science Education for Scientific Literacy). 2019. Available online: http://icaseonline.net/parsel/www.parsel.uni-kiel.de/cms/indexe435.html?id=home (accessed on 6 August 2019).

Potvin, P., and A. Hasni. 2014. Interest, motivation and attitude towards science and technology at K-12 levels: A systematic review of 12 years of educational research. *Studies in Science Education* 50: 85–129. [CrossRef]

PROFILES (Professional Reflection-Oriented Focus on Inquiry-Based Learning and Education through Science). 2019. Available online: www.profiles-project.eu (accessed on 6 August 2019).

Rannikmäe, M. 2002. Science teachers change towards STL teaching. *Journal of Baltic Science Education* 2: 75–81.

Reid, N., and E. Skryabina. 2002. Attitudes towards physics. *Research in Science and Technology Education* 20: 67–81. [CrossRef]

Salonen, A., S. Kärkkäinen, and T. Keinonen. 2018. Career-related instruction promoting students' career awareness and interest towards science learning. *Chemistry Education Research and Practice* 19: 474–83. [CrossRef]

Sheldrake, R. 2018. Changes in children's science-related career aspirations from age 11 to age 14. *Research in Science Education*. [CrossRef]

Simon, S., and K. Richardson. 2009. Argumentation in school science: Breaking the tradition of authoritative exposition through a pedagogy that promotes discussion and reasoning. *Argumentation* 23: 469–93. [CrossRef]

Simon, S., S. Erduran, and J. Osborne. 2006. Learning to teach argumentation: Research and development in the science classroom. *International Journal of Science Education* 28: 235–60. [CrossRef]

Stuckey, M., A. Hofstein, R. Mamlok-Naaman, and I. Eilks. 2013. The meaning of 'relevance' in science education and its implications for the science curriculum. *Studies in Science Education* 49: 1–34. [CrossRef]

Tilbury, D. 2011. Education for Sustainable Development: An Expert Review of Processes and Learning. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000191442 (accessed on 6 August 2019).

Tolppanen, S., I. Jäppinen, S. Kärkkäinen, A. Salonen, and T. Keinonen. 2019. Relevance of Life-Cycle Assessment in Context-Based Science Education: A Case Study in Lower Secondary School. *Sustainability* 11: 5877. [CrossRef]

UNESCO. 2005. Contributing to a More Sustainable Future: Quality Education, Life Skills and Education for Sustainable Development. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000141019 (accessed on 6 August 2019).

UNESCO. 2009. Review of Contexts and Structures for Education for Sustainable Development. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000184944 (accessed on 6 August 2019).

UNESCO Education for Sustainable Development Goals. 2017. Learning Objectives. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000247444 (accessed on 6 August 2019).

United Nations. 2015. Transforming Our World: The 2030 Agenda for Sustainable Development A/RES/70/1. Available online: https://sustainabledevelopment.un.org/sdg4 (accessed on 6 August 2019).

van Aalderen-Smeets, Sandra I., Juliette H. Walma van der Molen, and Iro Xenidou-Dervou. 2018. Implicit STEM ability beliefs predict secondary school students' STEM self-efficacy beliefs and their intention to opt for a STEM field career. *Journal of Research in Science Teaching* 1–21. [CrossRef]

Wals, A.E.J. 2011. Learning Our Way to Sustainability. *Journal of Education for Sustainable Development* 5: 177–86. [CrossRef]