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Published in:
International Journal of Designs for Learning

DOI:
10.14434/ijdl.v12i3.31656

International Journal of Designs for Learning
2021 | Volume 12, Issue 3 | Pages 118-128

CAREER-BASED SCENARIOS AS A MECHANISM FOR FOSTERING STUDENTS' INTEREST IN SCIENCE AND UNDERSTANDINGS OF STEM CAREERS

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Our purpose in this paper is to shed light on the intricacies of designing and enacting curricular innovations aiming to enhance students' interest in science and their understandings of STEM careers. We present the design and describe the implementation of a set of STEM career-oriented curriculum materials referred to as *career-based scenarios*. A review of the literature demonstrates that such curricular innovations create potentially useful mechanisms for broadening students' awareness of STEM careers and facilitating more informed decisions. We present the design process we followed to create career-based scenarios and we provide a rationale for each design decision. We also provide a description of the implementation of one representative scenario in three school classrooms. We conclude with a reflective section in which we identify reflections from our experiences and broader implications for curricular innovations targeting students' interests.

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INTRODUCTION

Much has been written over the last two decades about the importance of increasing the numbers of people in Science Technology Engineering Mathematics [STEM] fields (Organisation for Economic Co-operation and Development [OECD], 2019). The available statistics indicate that the share of STEM graduates remains lower than graduates in other fields (e.g., business, law, administration) at a critical time when our societies need more STEM professionals to tackle challenges regarding public health, sustainable living, and economic wealth (European Centre for the Development of Vocational Training [Cedefop], 2018). Responding to this need, we reflect on the design and implementation of the curriculum materials aimed at supporting students' development of understandings about STEM careers and potentially enhance their interest in pursuing STEM careers.

Empirical research provides evidence of how various factors influence young people's interest and career aspirations in STEM areas. These include personal attributes (i.e., cognitive and affective), personal background (i.e., parents educational background, socio-economic status, science capital), surrounding environment (e.g., significant others, educational opportunities) and school environment (e.g., context, teaching and learning practices, teachers' role) (Henriksen et al., 2015). Evidence from a systematic review shows that school factors have a crucial role in shaping STEM studies and career aspirations affecting all these facets (Reinhold et al., 2018). This evidence suggests the need and importance

https://doi.org/10.14434/ijdl.v12i3.31656

of pedagogical innovations for reforming the perceptions of science in school classrooms. In efforts to enhance the authenticity of school science experiences and broaden the scope of how STEM experts are perceived, researchers argued for inquiry-based interventions that engage students in scientific practices (Constantinou et al., 2018) and interactions with experts that serve as role models (Potvin & Hasni, 2014; van den Hurk et al., 2019).

The research literature shows that young people lack awareness about STEM careers which hinders the formation of STEM career aspirations (Blotnicky et al., 2018; Cleaves, 2005; Maltese & Tai, 2011). Research studies have also provided evidence that many initiatives in science education aiming to broaden participation in STEM fields are perceived by teachers and other stakeholders as short-term, fragmented and stand-alone interventions isolated from school curricula with a non-significant impact on students' career aspirations. For example, Kudenko et al. (2017) examined 79 school-industry initiatives across 14 EU and EU partner countries to foster students' aspirations towards STEM careers and found that a great number of these initiatives were short-term with a minimal contribution from industry representatives in promoting career awareness or aspirations. Likewise, Archer et al. (2014) investigated the impact of an intervention on 9th graders based on a school-industry collaboration. The findings indicated that in spite of broadening students' understanding of science jobs, the intervention did not change significantly their personal aspirations or views of science. These findings point to the need for infusing career-oriented instruction in STEM school curricula through carefully designed STEM engagements with the potential to empower students in making informed career decisions. Creating opportunities for classrooms to interact with practicing scientists and connections with curricular topics have been identified as two important parameters to be taken into consideration when designing pedagogical innovations for this purpose (Emembolu et al., 2020; Reiss & Mujtaba, 2017).

In an attempt to address this challenge, in this paper, we present the design and describe the implementation of a set of STEM career-oriented curriculum materials referred to as *career-based scenarios* that aimed at supporting students in developing an understanding of the diversity of STEM careers.

STEM CAREER-BASED SCENARIOS

In this section, we present the career-based scenarios developed as part of an EU-funded project (MultiCO), a collaboration between institutions in five countries. The overarching goal of the project was to enhance students' interest in science through fostering STEM career awareness. To achieve this goal, each country designed and developed a set of career-based scenarios to be implemented in science classes. It is important to note that in the case of Cyprus, presented in this paper, all the scenarios except for the first shown on Table 1 were designed and developed within the country context and then integrated into the curriculum through a context-based approach to relate to students' daily life and school science content as we present next (Drymiotou et al., 2021). Hence, context-related scenario adjustments were not necessary.

A career-based scenario is a story referring to a socio-scientific issue (e.g., climate change, energy, public health) that creates a need for connecting with a STEM expert (e.g., energy efficiency consultant). In the design of these scenarios, we paid special attention to how they integrate into science teaching units that were already established in the schools we collaborated with. We also devoted time and effort in supporting the teachers so that substantial aspects of the design rationale were showcased during the implementation. Our collaboration with participating schools evolved in three phases: (1) Design of career-based scenarios; (2) Scenario enactment in science class; and (3) Research evaluation. In this paper, we present the first and second phases, which occurred throughout the duration of our project:

Phase 1: Design of career-based scenarios

First, we decided on a set of design principles that were adopted for developing the career-based scenarios. Examples of such features are the following: personally relevant topic and context; problem-based activities; interaction with experts; ICT tools; group work; reflection activities. We arrived at these features as sources of interest in science through a synthesis of prior research findings derived from empirical studies aimed at developing student interest (Palmer, 2009; Rotgans & Schmidt, 2017).

Following that, we worked with teachers to identify appropriate teaching units as part of the national science curriculum to incorporate the scenarios and conducted experts that would act as role models. Drawing on the research literature we were careful to work with possibilities that had the potential to challenge the 'genius scientist' stereotypical view as well as gender stereotypes in relation to science careers.

We developed each scenario in the context of a topical socio-scientific issue with global relevance and local implications. Scenarios sought to make explicit connections with students' everyday lives and the public discourse that was accessible to them. Once we had an initial idea for a scenario, we explored how it could fit within the existing school curriculum. We looked through established teaching units and sought to attain a common understanding of the structure of the teaching-learning sequence. We jointly addressed, in collaboration with the teachers, the need to identify specific stages in the sequence that were suitable for embedding a career-based scenario. In subsequent work, we took into full consideration time restrictions, the frame of the

SCENARIO	SCIENCE TEACHING UNIT/GRADE	SOCIO-SCIENTIFIC ISSUE	SCENARIO MAIN FEATURES	CAREERS
CRIME SCENE: THE MYSTERIOUS CASE OF JULIANA	Electricity Grade 8	• Reduce energy use	'Be the expert' activity / Mission: to find out the cause of death, group-work, experiment	• Electrician • Horticulturalist • Forensic • Chemist • Pharmacist • Zoologist
ZERO PLASTICS TO LANDFILLS BY 2020	Pure and Impure Substances Grade 8	• Plastic waste • Need for recycling	'Be the expert' activity / Mission: to learn about plastic recycling process, comic strip/role-play, video call with the expert (male), poster design and presentation	• Environmental Scientist
NUCLEAR DECISIONS	Sustainable Development Grade 8	• Nuclear power – radioactivity • Environment Protection	'Be the expert' activity / Mission: to decide which country is best to host a nuclear plant according to location parameters as to have minimum risks, text-based information for careers, variety of sources based on statistic and scientific data, group work	• Geologist • Environmentalist • Hydrologist • Seismologist • Meteorologist
MISSION OBESITY	Nutrition Digestive system Circulatory & respiratory system Grade 8	• Obesity	'Be the expert' activity / Mission: to take on the role of an expert and decide how this expert could help the obese man, text-based information for careers	• Biologist, • Cardiologist, Gastroenterologist, Dietician
ACOUSTICS CLUB	Waves and Sound Grade 8	• Sound quality • Noise pollution	'Be the expert' activity / Mission: to turn school squash court into night-club, role-play, video, modeling, expert's visit (male)	• Acoustic & Mechanical Engineer • Physicist
FLY IF YOU CAN	Forces Grade 8	• Transport • Emergency landing /problems during take off	'Be the expert' activity / Mission: to build mini-airplanes, video-interview with expert (male), experimentation	• Aeronautical & aircraft engineer • Mechanical & electrical engineer
TWO-WHEELED MISSION	Speed and Motion Grade 9	• Transport & Environment • Car emissions • Traffic congestion	'Be the expert' activity / Mission: to choose the optimal cycling route, group-work, expert's visit (female)	• Civil Engineer • Transport Engineer
SAVE THE POLAR BEARS	Heat transfer Grade 9	• Climate change • Energy efficiency	'Be the expert' activity / Mission: to test energy-efficient materials, experiment, experts' visit (female & male)	• Architect/ • Civil engineer • Physicist

TABLE 1. Description of the career-based scenarios.

teaching-learning sequence, the issues that students would be engaged with, and how the scenario could fit seamlessly with prior and follow-up activities. The teachers had a significant role in refining these activities based on students' prior knowledge, the learning objectives, and time restrictions before each enactment. In each case, participating experts had an important role in offering feedback on students' mission and formulating the main questions driving the scenario. Table 1 summarizes the eight career-based scenarios that were implemented providing details about the teaching unit they were embedded in, the socio-scientific issue, the main features, and the careers addressed in each scenario.

PHASE 2: SCENARIO IMPLEMENTATION

The second phase of the project was devoted to the implementation of each scenario in secondary school classrooms. In total, there were five scenario sessions comprising the intervention, which were implemented in a period of two years. We chose to work with grades 8 and 9 (13 -15 years old), given research evidence showing that students' interest in science declines during the transition from primary to secondary education (Potvin & Hasni, 2014). Each session was extended over 3-13 teaching periods (35'-50') depending on the teaching unit and the schools' time restrictions. A typical session was structured as follows: introductory scenario presentation and its connections to the teaching unit, follow-up activities transitioning back to the teaching unit and then a reflection phase to summarize the main outcomes of the sessions in terms of conceptual goals and understandings of STEM careers.

It is important to note that each intervention followed a design-based participative research approach. Hence, the scenarios and the teaching sequence were developed through five cycles that we refer to as *sessions*, as illustrated in Figure 1. As shown, some scenarios were implemented in more than one session.

AN EXAMPLE FROM CLIMATE CHANGE: SAVE THE POLAR BEARS

In what follows, we present an indicative example of a career-based scenario, which was implemented only in session 5 in the teaching unit on heat transfers in grade 9. The goal of the session was to examine concepts related to climate change.

In addressing this goal, the activities focused around energy efficiency and on introducing the careers of an architect, a civil engineer and a consultant on energy efficiency. This scenario was implemented in three classrooms (Enactment A, B, and C, respectively) by different physics teachers during session 5 and covered 3-4 teaching periods (35'-50'). In the next section, we present the scenario and describe the three enactments in chronological order alongside the rationale for design adaptations. Table 2 presents the similarities and differences between the design of the scenario and adaptations in each implementation. It is important to note that the scenario was adapted according to teachers' feedback and researchers' reflections considering students' interest and engagement in the activities. In the next section we present each enactment in terms of its focus, the presentation of the scenario, the experimentation and the reflection phase.

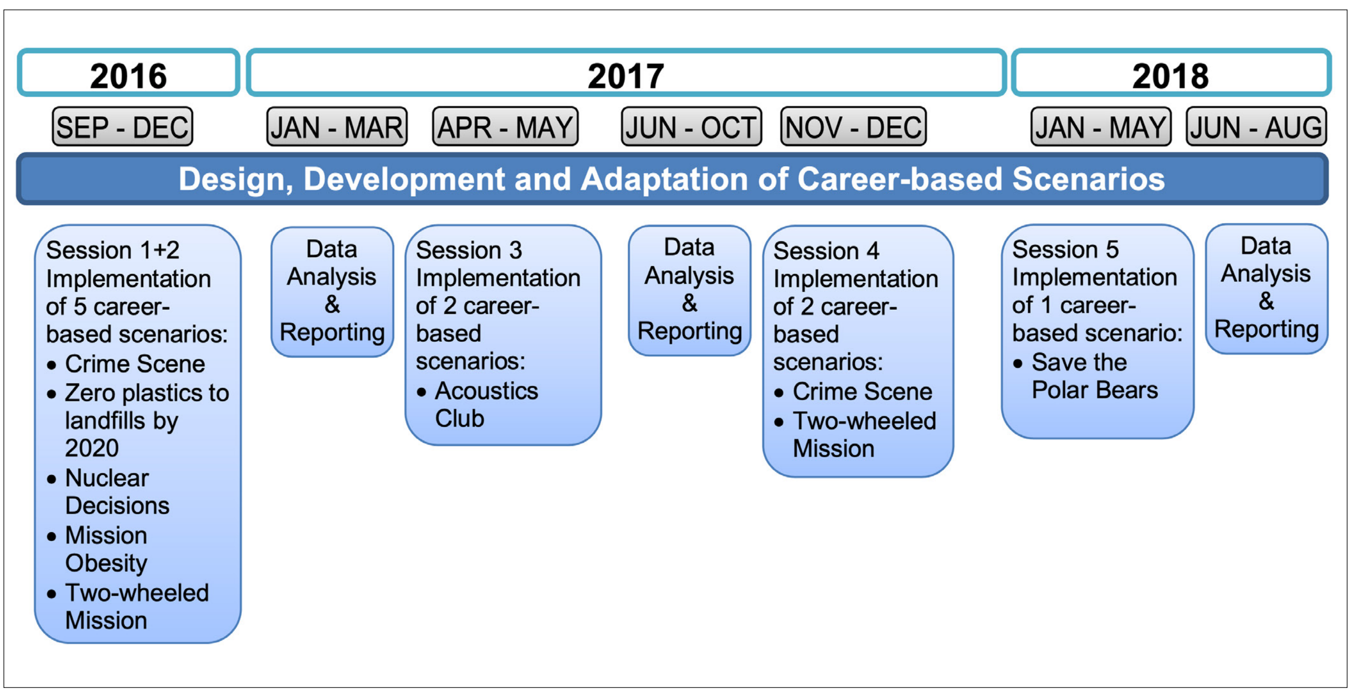


FIGURE 1. Timeline of the intervention.

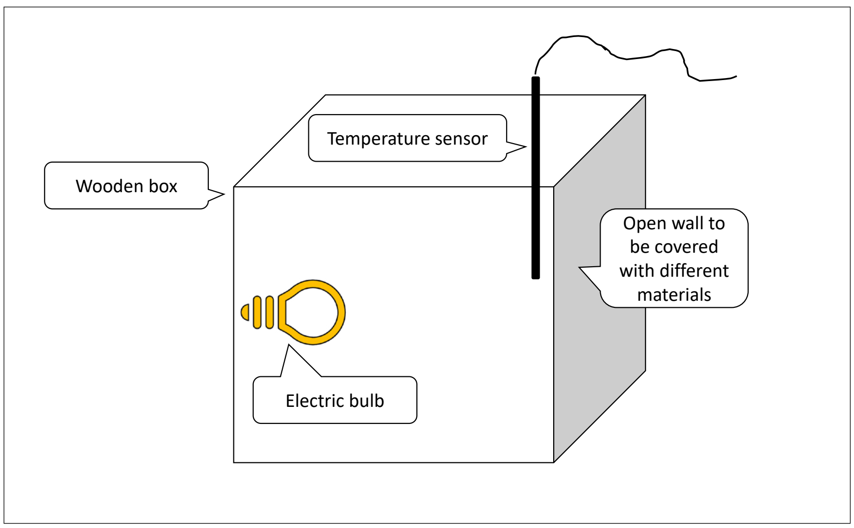
<table>
<tr><th>STRUCTURE</th><th>ENACTMENT A</th><th>ENACTMENT B</th><th>ENACTMENT C</th></tr>
<tr><td rowspan="3">Introductory scenario presentation and its connections to the teaching unit</td><td colspan="3">Video showing a starving polar bear and follow up discussion about climate change consequences focusing on how energy can be saved (link to energy efficiency).</td></tr>
<tr><td>Text-based career-related information from one company, presented on PowerPoint slides. The students were given a worksheet to keep notes on how to reduce heat transfer in different parts of a house. considering conduction, convection, and radiation</td><td>Video (10 min) showing interviews with the experts (female and male) working at the company (information on personal and work life).</td><td>Video was trimmed (5 min).</td></tr>
<tr><td colspan="3">Announcement of the mission: to test energy-efficient model-houses, contributing to mitigation of global warming, considering the role of architects and engineers specialized in energy-efficiency.</td></tr>
<tr><td rowspan="2">Experimentation / Follow-up activities transitioning back to the teaching unit</td><td colspan="3">The students worked in groups to test the insulation of different materials using temperature sensors and a software program (Coach 6 Lite) after a short demonstration. The students covered the open wall of the wooden box with different materials as shown in Figure 2 below:


FIGURE 2. Design of an energy-efficient house.
The students were provided with instructions about the experimentation process and tables to record their measurements. The teacher provided support and each group had one facilitator (researcher).</td></tr>
<tr><td>Each group tested three materials and noted the time needed for the temperature of the house to increase by 5 degrees Celsius and then decrease by 5 degrees Celsius after turning off the bulb.</td><td colspan="2">Each group tested one material (different) and noted the time needed for the temperature of the house to increase by 10 degrees Celsius and then decrease by 10 degrees Celsius after turning off the bulb.</td></tr>
<tr><td>Experts' Visit and Reflection phase</td><td>Experts' visit and presentation guided with PowerPoint slides. One lesson followed to revise the experiment.</td><td>No experts' visit. Discussion with teacher about the best material to use for insulation.</td><td>Experts' visit planned in collaboration with the researchers and the teacher.</td></tr>
</table>

TABLE 2. Description of the three enactments of the scenario 'Save the Polar Bears' with details on the adaptations.

We also elaborate on the decisions made for the design adaptations.

Scenario description

The scenario was introduced to the students through a problem-based approach as follows:

> *Climate change threatens the lives of polar bears due to the rise in temperatures and the melting of sea ice. Climate change also affects the entire planet in other ways (photos from floods, droughts, fires) and highlights the need for energy efficiency to mitigate its effects.*

The scenario also includes information about how the extensive energy needed for heating and cooling our buildings comes from fossil fuels emphasizing that part of the increase in global temperature results from increases in carbon dioxide levels in the atmosphere. The students' mission was to evaluate the energy efficiency of house models by testing the thermal conductivity of different materials on wooden boxes that simulate real houses. The mission highlights an effort to help address global warming and save financial resources by assuming the expertise of architects and engineers who specialize in energy efficiency.

Enactment A

Focus

The researchers in collaboration with the teacher decided to focus on the establishment of useful connections between theory and practice emphasizing the scientific method and the interaction with experts. More specifically, the aim was to first facilitate the students formulating and testing hypotheses, and then drawing and verifying conclusions while sharing their results with the experts.

Scenario presentation

During the first lesson, the teacher communicated the learning objectives to the class, which was followed by a screening of a short video. The video showed a skinny and starving polar bear looking for food in a trashcan. The bear collapses onto the ground after finding nothing. Following the screening, the teacher engaged the students in a discussion about climate change and its consequences. The discussion broadened out into the various effects of climate change, including flooding and global warming as well as the important role of fossil fuels in releasing greenhouse gases into the atmosphere. The teacher introduced the idea of 'acting locally, affecting globally' (*Why should we care?*) and the discussion shifted to measures for mitigation and reversal of climate change with an emphasis on personal and local community responsibility as well as on the need to look out for the interests of future generations. The classroom discussion focused on how energy can be saved establishing a link to 'insulation'. Departing from that, the teacher introduced the concept of 'energy efficiency and then the mission which was linked to the profile of a company with architects and engineers specialized in energy-efficient building, by providing text-based information on the experts' educational background, job duties and skills. At the end of the lesson, the teacher shared a worksheet to help students formulate hypotheses on how to reduce heat transfer in different parts of a house via conduction, convection, and radiation.

Experimentation

In the second lesson of the session, the teacher began by reminding students of their mission. The students worked in groups to test different materials with different thicknesses (e.g., Styrofoam, bubble paper, wood, cardboard, aluminum, and plastic) and record their measurements. After the experimentation, each group presented their results.

Reflection

In the third lesson of the session, two experts (architect/engineer and physicist) visited the students in their class. Before the visit, we communicated with the experts after having been asked to prepare a short presentation to show their work, explain how it relates to students' mission, and also share information about their everyday life outside the work environment. Hence, the experts introduced themselves and then started a lecture-type presentation focusing mainly on their work.

One lesson followed to test more materials reflecting on the information provided by the experts. By the end of the lesson, the teacher collected all the measurements on the whiteboard. The students compared their measurements and realized the importance of controlling variables in scientific experiments (e.g., the use of different materials with the same thickness). The teacher discussed scientific methodology as a way of conducting fair tests as well as the importance of repeating measurements in order to increase validity and ensure reliability.

Reflecting on the first implementation of the 'Save the Polar Bears' scenario, we considered that the experimentation process provided the students with a better understanding of scientific methodology and also the concepts of heat loss, insulation, and energy efficiency (e.g., "*I really liked it when we did the experiment on our own. Most of the times we are being told many things, but we don't really do testing. However, that way we could take over and do the experiment using the software on the computer and this was a great experience"* [Student A1]). Nonetheless, we acknowledged that the students were not always actively involved in a discussion with the experts and even though the overall experience was informative, the experts' visit was perceived as boring (e.g., "*I think we weren't involved in it. I think they were just telling us* [Student A2]; *Perhaps they could have done more hands-on things to get more involved, engaged* [Student A3]; *The*

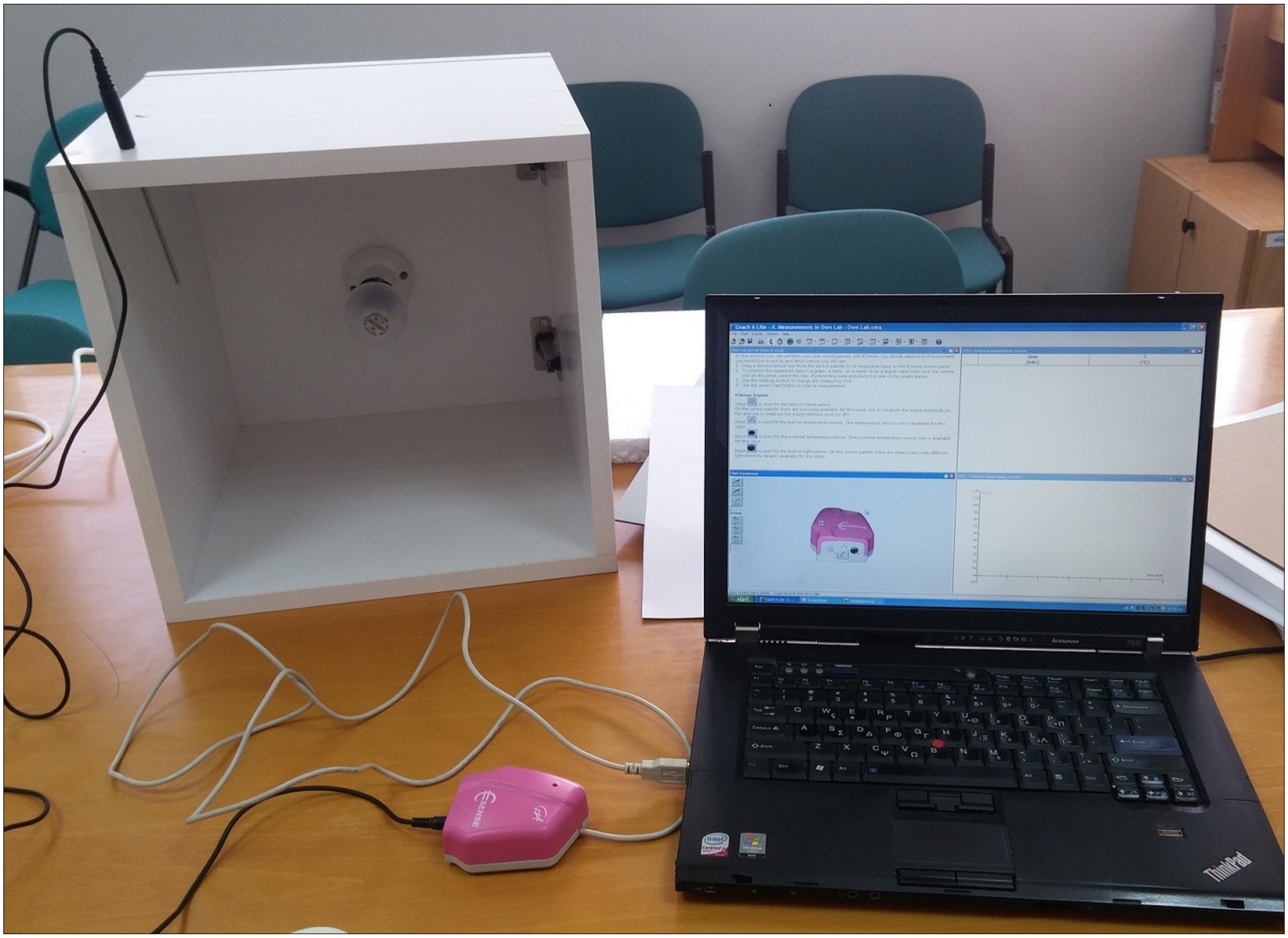


FIGURE 3. Wooden box as a model for an energy-efficient house with a temperature sensor using Coach 6 Lite.

students became bored during the experts' presentation - the presentation style was hesitant and not engaging" [Teacher A]). Hence, our aim for the next implementation was to foster an engaging experience with the experts and consider the careers as a dominant aspect. In doing so, we decided that an introduction with the experts before the visit would be useful. Therefore, we revised the design of the scenario by replacing the text-based information in the first lesson with video interviews, which we conducted and recorded with the same experts who had visited the students. We assumed that sharing of personal information with respect to the experts' everyday life through the videos could set the ground for an informal interaction with the experts during their visit, thus facilitating the reconstruction of stereotypical ideas about scientists' lives and the nature of their work (Avraamidou, 2013).

Enactment B

Focus

In this case, the emphasis was to raise students' environmental awareness and introduce green career choices in relation to theoretical concepts on heat transfer.

Scenario presentation

First, similar to Implementation A, the National Geographic video was presented and then the teacher engaged the students in a discussion about the causes of climate change and possible consequences. The discussion shifted to suggesting ways to save energy based on everyday experiences (e.g., the use of air-conditioning during hot days). The teacher introduced the experts as people working on promoting ways to restrict heat loss and save energy thus contributing towards protecting the environment. Then the video interviews were presented, and the teacher discussed the careers with the students focusing on prior knowledge while making links to practical applications of the concept of heat transfer in order to announce the mission for investigation.

Experimentation

In this implementation cycle, the second lesson pertained also to the experimentation with minor changes to facilitate the process and making comparisons between the groups (see Table 2). For example, each group tested one material with the same thickness (ceramic, wood, bubble paper). After announcing the results, the teacher prompted the students to make comparisons between the different materials and make predictions about other materials (e.g., metal and glass). Given the 35-minute teaching periods, these changes served to speed up the experimentation process through the distribution of labor while safeguarding the importance of controlling variables in scientific experiments.

Reflection

In this final lesson, the teacher discussed the results of the experiments and focused on addressing the goal of learning about experimental design. Furthermore, the teacher extended the discussion to the materials the experts use for insulation purposes showing extracts from the video interviews with a reference to these materials.

To sum up, in the second implementation cycle we focused on raising students' environmental awareness through developing fruitful discussions and facilitating the experimentation process with emphasis on the use of a 'fair test'. The students responded favorably to this approach (e.g., "*I liked it because we learnt about social issues we weren't really aware of* [Student B1]; *The most interesting part was the experiment when we had to measure time and temperature and it was really nice"* [Student B2]). Moreover, it seemed that the more personal information about the experts presented through the video interviews were more interesting for the students. Hence we decided to shorten the interviews and provide answers to questions related to job responsibilities, the reasons for choosing the specific career, relevant studies and required skills, feelings towards practicing the job and everyday routines. Some indicative questions were the following: What is your job, what did you study and why? Could you describe a typical day at work? Do you like your job? What is the most/least interesting thing in your work? Do you need to have certain skills to do this job? How many hours per day do you work? What hobbies do you have? Then, we considered that a combination of the revised video-interviews and the experts' presence in the classroom would strengthen students' understandings of these careers. Therefore, before the next implementation we also arranged a meeting with the experts and discussed how to address social stereotypes about scientists and their work.

Enactment C

Focus

In the final implementation of this scenario, the focus was similar to the previous cycle emphasizing the establishment of useful connections between theory and practice with the experimentation and meaningful interaction with the experts. Hence the purpose was twofold: to transfer the physics concepts to a real-life context as a means to overcome barriers that had arisen from presenting a subject disconnected from real life, and then strengthen this understanding through the interaction with the experts.

Scenario presentation

During the scenario presentation, the students were engaged in discussion about the starving polar bear, expressing ideas about climate change, the greenhouse effect, and the impacts on the environment. The teacher, reflecting on the discussion that unfolded, prompted the students to take the initiative and formulate investigable research questions. Then, the mission was announced, and the teacher presented the video-interviews of the experts.

Experimentation

The process of experimentation was identical to the second implementation. The students seemed to be interested in taking ownership of the learning tasks.

Reflection

In this last lesson, the teacher summarized the results from the experiments and discussed with the students about which material was found to be a better insulator. Next, the teacher welcomed the expert, who initially commented on students' findings and then explained how insulation is fitted, what materials are used and also gave real-life examples and referred to applications of insulation on houses, the school building, and places familiar to the students. Moreover, it was observed that some students who had not contributed to previous lessons, started asking the expert not only work-related questions but also personal questions about his routine, his life outside working hours, even his outfit since he was casually dressed.

Considering the final implementation, during the first lesson there was a classroom discussion about climate change and the consequences to the environment emphasizing the energy loss. Nevertheless, it appeared that the following lessons were more engaging and interesting for the students (e.g., "*To be honest I didn't really like the first lesson, I felt bored. I liked the 2nd and 3rd lesson because we had things to do, experiments. In lesson 2 we had to work as a team and lesson 3 was nice because we learnt information about a job from an expert"* [Student C1]). It was clear that students' engagement was enhanced once they started experimenting (e.g., '*The most interesting part was the experiment because we had to do investigations, and we were not being told the answer* [Student C2]). Then, students' excitement peaked during the expert's visit (e.g., *'He told us many things about insulation and in general I understood what he does in his job, what's the difference* *between an architect and a civil engineer because it was all messed up in my head'* [Student C3]; '*It was interesting because we could ask the expert whatever we wanted and you don't get opportunities like that every day – I mean get to know someone expert'* [Student C4]). Additionally, the video interviews with the experts in the first lesson facilitated the introduction of the expert in the final lesson and prompted the students to ask questions based on the information shared through the video interviews. Hence, the combination of video interviews prior to the presence of the experts in the classroom was considered useful in facilitating the interaction with the students.

REFLECTIONS

The purpose of this paper was to present the design rationale and development process of curriculum materials referred to as *career-based-scenarios*. In doing so, we aim to provide readers with an understanding on how we proceeded from the design to the enactment of these materials following a design-based participative research approach.

To illustrate our description, we have used the scenario 'Save the Polar Bears' as an indicative example which was developed over three cycles of enactment in three secondary school classrooms. Reflecting on the iterations, we reached a consensus with the teachers as to how such curriculum materials might support students in developing an understanding of the diversity of STEM careers. During the whole process, we also had to address two issues of great importance to our partner teachers and schools: (a) time restrictions due to the school timetable that usually constrained the duration of an enactment, particularly the students' mission and interaction with experts, and (b) relevance of the scenario to the teaching unit and seamless transitions from the scenario to the follow-up activities and back to the unit.

In what follows we provide a list of reflections from our process of design-enactment-revision.

Reflection 1: Personally relevant content

We found that it was important to frame the scenarios as part of established science teaching units, in a personally relevant context using authentic and real-life socio-scientific issues that were more engaging for students and facilitated the link to careers that address such global challenges. For example, the 'Save the Polar Bears' scenario was linked to climate change and its impact on the environment which is highlighted in the media as a critical issue of global public concern.

Reflection 2: Use of engaging media

The use of a video with the disturbing footage of the starving polar bear served to emotionally engage the students and initiate a discussion about how acting locally has a global impact. We found that this discussion between the teacher and the students established a link between the scenario and the teaching unit, which prompted the students to share everyday experiences and enabled the teacher to introduce the concept of energy efficiency, the mission for experimental investigation and the relevant careers.

Nevertheless, identifying an engaging medium to portray the professional and personal life of the experts was not successful. The presentation of text-based information using slides (Enactment A) and the use of long video-interviews (Enactment B) seemed uninteresting for the students. On the other hand, shorter video-interviews in combination with life presence of the experts in class was perceived as much more interesting (Enactment C).

Reflection 3: Mission-driven design

We found that setting a problem in the form of a mission at the start of a career-based scenario was more likely to engage the students in scientific practices, promote the feeling of ownership towards learning progress, and help students in establishing useful connections between theory and practice. Minor adaptations, such as in the experimentation process, throughout the three cycles of enactment (e.g., different materials for testing with different thickness) served to optimize the teaching-learning sequence and to better enabling the students in understanding the core ideas, such as the importance of conducting a fair-test.

Reflection 4: Engaging experts

Based on our observations, the interaction with experts served as an essential feature of career-based scenarios in fostering students' understandings of STEM careers. We can argue that the third implementation of the scenario 'Save the Polar Bears' might be seen as an example of 'good practice' in having enhanced students' understandings of STEM careers. First, it was observed that planning the visit ahead of time, in collaboration with the experts, as well as presenting in advance the short video-interviews served as a catalyst, setting the ground for developing a connection with the students. Then, during the visit, the expert was able to make successful connections between students' mission/experimentation and professional practices, while managing to communicate career advice and life-long messages such as persistence in overcoming obstacles. More specifically, the expert had the flexibility to be responsive and made the effort necessary to meet the students' curiosity half-way, offering a lively perspective in considering career choices and job seeking, something that is usually neglected by school career advisors. Significantly, we believe that such personal interactions with experts, given the informal discussion and the casual outfit of the expert, are important for facilitating the reconstruction of stereotypical ideas about scientists' lives and the nature of their work (Avraamidou, 2013).

To conclude, we suggest that career-oriented curriculum materials have the potential to provide opportunities for active engagement in scientific practices, interaction with experts, and consequently to support students' development of understandings about STEM careers. Hence, we recommend the integration of career-based scenarios in science teaching and learning as a response to the challenge of enhancing students' interest in science as well as helping them to take an informed stance towards their future study and career-choices (Blotnicky et al., 2018; Reiss & Mujtaba, 2017). We further argue that such career-oriented materials could be integrated in informal science learning spaces (e.g., science centres and makerspaces) with the potential to promote fruitful collaborations with industry partners and engage young people in experiencing authentic STEM-related workplace environments. Thus, a recommendation for exhibit designers and those involved in informal science learning spaces is to focus on the design of career-based scenarios (phase 1) as discussed above and then, through in-situ observations and other data, make the appropriate implementation adjustments depending on the learning setting, in order to maximise students' active engagement in science practices and interaction with experts.

ACKNOWLEDGMENTS

The design and implementation of these curriculum materials as well as the associated research were part of the MultiCO project, which was supported by the European Union through the Horizon 2020 program, Grant Agreement No. 665100 and the Youth Board of Cyprus.

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