Enhancing students’ interest in science and STEM careers

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CHAPTER 6: GENERAL DISCUSSION, REFLECTIONS AND RECOMMENDATIONS

6.1. GENERAL DISCUSSION

Young people's declining interest in pursuing STEM studies and careers has been a worldwide concern for over a decade (Gago et al., 2005; OECD, 2020). This downward trend rings alarm bells for the science education community and policy makers in view of a predicting mismatch between supply and demand for STEM professionals (CEDEFOP, 2018). Societies are faced with complex socio-scientific issues, such as threats to global health, that create the need for more STEM professionals to tackle these challenges and reach societies' targets for sustainable growth, economic development, and technological innovation. Hence, in this thesis, I was driven by a keen interest in enhancing students' interest in science and STEM careers and contribute towards increasing the numbers of STEM graduates.

As evidence in recent research, pedagogical initiatives have been implemented to enhance students' interest in science using non-conventional approaches such as inquiry and problem-based learning, collaborative instruction, contextualized interventions, and extra-curricular activities in authentic settings (e.g., Potvin & Hasni, 2014; van den Hurk et al., 2018). However, the majority of these initiatives were considered short-term or one-off activities isolated from the science curriculum with minimal interaction with STEM experts which usually failed in reconstructing the stereotypical image of the 'genius scientist'. These findings point to the need for providing connections between STEM careers and science curricular topics that may enhance students' interest in science and encourage them to consider choosing science-related subjects after compulsory education, thus increasing the potential to make STEM-related choices. On the other hand, the formation of career aspirations and choices is a complex and evolving process that extends beyond the boundaries of a science classroom which interferes with students' self-view. Research has also revealed an interplay between interest and self-view influenced by an array of extrinsic and intrinsic factors in predicting STEM study and career aspirations which remains underexplored during adolescence, a critical phase for identifying career choices (Reinhold et al., 2018).

In efforts to contribute towards bridging this knowledge gap and also provide the science education community with innovative curriculum resources, primarily, the aim of this project was to investigate students' interest in science and understandings of STEM careers using career-driven curricula and then, further explore the factors influencing their self-views in relation to science and STEM career aspirations. In approaching the interplay of interest in science and self-view in relation to science we framed this research project within the Social Cognitive Career Theory (SCCT) model (Lent et al., 1999). The SCCT model serves to understand how people develop interest and make career-related choices and actions, considering the interaction between personal dynamic aspects (e.g., interest, self-view) and the surrounding environment.

This thesis reports on a longitudinal project consisting of one study that focuses on the curriculum design and three empirical studies using questionnaires and individual semi-structured interviews with the students and the teacher(s). First, I presented the process of design and implementation of the career-driven curricula providing insights into career-oriented curriculum design and support to educators (**Chapter 2**). Next, I reported the findings from a scenario implementation in two science classrooms using an iterative design-based approach focusing on what features work best to generate students' interest and enhance their understandings of STEM careers (**Chapter 3)**. Then I presented a classroom-based study providing insights on enhancing students' interest in science and understandings of STEM careers over a two-year intervention with the integration of five scenarios in science teaching units (**Chapter 4**). Last, I provided insights to further theorize the development of students' self-view in relation to science and STEM career aspirations with a focus on the factors influencing this evolutionary process (**Chapter 5**).

In this final chapter (**Chapter 6**) I highlight the main findings that emerged from the four presented studies. Next, I discuss the significance of these findings and end the chapter with implications for theory, research, and educational practice alongside recommendations for future research.

6.2. MAIN FINDINGS

6.2.1. Career-based scenarios as a mechanism for fostering students' interest in science and understandings of STEM careers

The first step was to design, develop, and implement the career-driven curricula referred to as *career-based scenarios* which are stories related to socio-scientific issues (e.g., climate change, energy, public health) that create the need for connecting with a STEM expert (e.g., energy efficiency consultant). Therefore, the purpose of the study in Chapter 2 was to present the process we followed in doing so. First, we presented the design process in three steps providing a rationale for each design decision. Then, we provided a description of the implementation of a representative scenario in three classrooms (grade 9, 14-15-year-old students) using a design-based participative approach which was structured as follows: (a) introductory scenario presentation and its connections to the teaching unit; (b) follow-up activities transitioning back to the teaching unit; and (c) a reflection phase to summarize the main outcomes of the sessions in terms of conceptual goals and understandings of STEM careers. To conclude, we reflected on this iterative process to identify the lessons learned and provide broader implications for curricular innovations targeting students' interest and understandings of STEM careers. These are summarized next:

- Framing the career-based scenarios in a personally-relevant context as part of already established science teaching units with references to authentic and real-life socio-scientific issues was more engaging for students. This approach also facilitated linking to careers that address global challenges.
- Using engaging media can serve as a starting point for presenting the career-based scenarios and prompting a discussion with the students, thus establishing a link between

the scenario and the teaching unit. However, the use of media is not always interesting for the students. For example, when portraying the professional and personal life of a STEM expert, a combination of media with the live presence of the experts was perceived as much more interesting.

- Setting a problem in the form of a mission facilitated students' engagement in scientific practices and promoted the feeling of ownership towards the learning progress. It was also indicated that the mission helped the students in establishing connections between theory and practice.
- Promoting personal interactions with STEM experts was considered an essential feature of the career-based scenarios in fostering students' understandings of STEM careers. It was found that students can develop a connection with the expert provided that there is a collaboration between the teacher and the expert(s) to carefully plan the visit ahead of time and set the ground. The informal discussion and the casual outfit of the expert also served to facilitate the development of a connection with the students and perhaps the reconstruction of stereotypical ideas about scientists.

We conclude that the findings of this study provide insights to inform science curricula in formal and informal learning contexts with 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. We further argue that such teaching innovations respond to the calls for pedagogical efforts to enhance young people's interest in study and career choices in STEM fields.

6.2.2. Strengthening students' interest in science: The case of 'Saving the polar bears'

The second step was to explore the impact of the scenario 'Saving the polar bears' on students' interest and understandings of STEM careers following two enactments in different science classrooms using an iterative design-based approach. The use of the same scenario served to understand what works better reflecting on the design adjustments to the scenario from the first to the second enactment. This study involved 39 students attending the 9th grade in two secondary schools (aged 14-15 years old) that formed a homogenous group in terms of cultural experiences, scientific knowledge, and social class. We collected data using two questionnaires (to evaluate the scenario and to measure the intensity of SI), field notes, and individual semi-structured interviews with the students and the teachers at the end of each enactment. The data from the questionnaire were analysed with the use of descriptive statistics and the interview data were analysed through content analysis.

The findings revealed that in both enactments the repeated use of novelty features in the scenario in terms of ICT tools (i.e., videos, software programme) and problem-based activities (i.e., 'be the expert' activity) with the subsequent experimentation served to trigger and sustain students' situational interest. Moreover, it seemed that presenting a global issue in science class with references to related careers framed within a personally-relevant context enabled the students to establish connections between theory and practice. This also facilitated the students to understand the value of science which potentially increased their interest.

Even though the students reported gaining basic career-related information in both cases (i.e., mostly associated with school science), what it was worth highlighting is that integrating the career aspect in collaboration with the experts and the teachers and promoting a more personal interaction with the experts (enactment B) than doing lecture-type presentations (enactment A), had a positive effect on enhancing students' interest. There were also indications that the informal interaction in the second enactment may have influenced the majority of the students in aspiring the career of an architect or civil engineer in the future (i.e., positive response to the statement 'This career might be an option for me'). This study provided some interesting findings in how to integrate the career aspect in science instruction.

6.2.3. Enhancing students' interest in science and understandings of STEM careers: the role of career-based scenarios

As a next step, we examined the impact of the implementation of five career-based scenarios on students' interest and understandings of STEM careers over two consecutive years in Chapter 4. This case study involved 16 students (aged 13-15 years old) who participated in a five-session intervention during grades 8 and 9. For the purpose of this study, we aimed to instantly trigger SI using the career-based scenarios, support this triggering by environmental stimuli in the classroom environment, and enhance students' understandings of STEM careers. Data were collected using a questionnaire and semi-structured interviews with the students at the end of each session. Quantitative data were analyzed using descriptive statistics and qualitative data using content analysis.

Overall, this study provided empirical evidence about the ways in which career-oriented curricula in science classrooms can enhance students' interest in science and understandings of STEM careers. These findings confirmed and enriched the results from the previous study. More specifically, the findings demonstrated certain scenario features that could possibly trigger students' SI and enhance their understandings of STEM careers as follows: (a) promoting students' active engagement through a problem-based approach that incorporates novel scientific practices; (b) establishing connections between classroom discourse and authentic workplace environments by transferring science concepts to a real-life-personally-relevant context; and (c) integrating the STEM career component through informal interactions with experts.

Considering these findings, we identify an alignment with what emerges from the previous study. We argue that this alignment further supports the integration of such teaching innovations in science curricula in efforts to enhance students' interest in science and STEM careers. Nevertheless, it was revealed that solely providing career awareness in meaningful ways framed within a personally-relevant context, did not result in more students exploring

STEM career options. We remark though that in this study we focused merely on students' learning experiences in the school context. Hence, in order to get an in-depth understanding of the complex process of forming career aspirations and inform science instruction, we conducted a third study to explore the factors influencing students' self-view in relation to science, and investigate the relationship with career aspirations.

6.2.4. Would a career in science suit me? Students' self-views in relation to science and STEM career aspirations

In this final study, in Chapter 5, we explored students' self-views in relation to science and STEM career aspirations over a five-year period. The purpose of this study was to develop a better understanding of the interplay between experiences with school science, factors relating to the social and family environment, evolving self-views during adolescence, and career aspirations. This longitudinal multiple case study involved eight students (13-17 years old) who participated in the classroom-based study (Chapter 4, grades 8-9) and agreed on participating in interview sessions for two more consecutive years (grades 10-11). Data were collected through semi-structured interviews at eight collection points and were analyzed using content analysis. Triangulation was achieved through teacher interviews and access to personal and family information through the school.

The analysis of the data yielded four profiles that portray students' self-views in relation to science in terms of their interests, goals, and actions, as incorporated in the SCCT model. These profiles are namely: (a) the *Altruist* with a compassionate and benevolent way of thinking, predisposition to help others, tenacity in biology, goals, and choices of science-related subjects; (b) the S*cience 'geek'* with immense curiosity to understand how the world works, passion for physics and relevant goals and choices; (c) the *Science offspring* with a negative or positive attitude towards science in response to family science capital and relevant goals and actions and, (d) the *Realist* with a measured perspective for life, an instrumental view of learning science and mainly non-STEM-related goals and actions. The evolution of students' self-views across the secondary school years revealed a stark contrast between the four profiles. *Altruists* and the *Science 'Geek'* seemed to draw on innate resources to formulate their interests and related goals and actions while it was found that the family and social environment play a critical role in shaping students' self-views for the *Science offspring* and the *Realist* profiles. Family science capital evokes emotional engagement with science which may be positive or negative for *Science offspring* until other agents act as new stimuli (e.g., positive school experiences). Furthermore, influences from the social environment were perceived mainly positively for the *Realists* that seems to have facilitated the process of identifying their goals and finding a pathway to self-fulfillment.

Further investigation revealed a dynamic interplay between the evolution of students' self-view and career aspirations (i.e., future expectations or visions to pursue a career in a STEM-related field) in light of extrinsic influences that become internalized through the years. Overall, the data analysis indicated that students' self-views in relation to science aligned quite well with their career aspirations (STEM-related or not). However, career aspirations varied within each profile and sometimes changed over time according to influences from the social context and the educational environment. The changes appeared to be drastic during lower secondary school years and more consistent and gradually more specific during the transition to post-compulsory education. The main mediating factors indicated to have had an impact in the evolution of students' self-views and career aspirations pertained to students' interests, personal passion and self-efficacy with respect to science, family values, and science capital, gender differences in terms of outcome expectations and values, school education experiences over time, as well as science-related hobbies and leisure activities. These findings served to enrich our understanding of students' behavioural and thinking patterns with regard to their self-view in relation to science and career aspirations.

6.3. LIMITATIONS

In this section, we indicate and elaborate on the limitations of these research studies with a focus on the research sample and methodology.

First, the 'locality' of the research context, combined with the method employed for choosing the sample and its size restrict the possibility for generalizing some assertions. Geographically, the students came from the capital of Cyprus and formed a homogeneous group with respect to socio-economic status (middle class), societal culture, and access to resources. The sample was also considered typical of the wider population of this country in terms of age, cultural experiences, and background scientific knowledge. Hence, the sample served to address the research questions of this project providing confidence that representativeness has been achieved (Maxwell, 2012).

Although the aim of the research project was not to produce data that could be generalized rather than to provide empirical evidence to inform career-oriented curriculum design, some may argue that the enactment of such teaching innovations in other contexts may not be possible due to the lack of contextual affordances. For instance, such constraints may associate with the lack of resources and particularly missing opportunities to collaborate with practising scientists (i.e., classroom visits, school-scientists joint projects) and the flexibility in altering the curriculum, especially in the case of centralized educational systems.

Additionally, our findings revealed a dynamic relationship between students' self-views in relation to science and their career aspirations which reflects influences from the social context, the family environment, and the educational environment. Evidently, this outcome confirms findings from previous research suggesting a strong role of family members and school experiences in shaping children's career aspirations which reflects a collectivist, family-centered culture (e.g., Archer et al., 2012; Aschbacher et al., 2010). Saldaña (2021) suggests that formulating generalizations in qualitative research is not useful but working towards making comparisons with other settings may possibly yield 'generic' findings that can be concretized. Hence, given the unique set of social and cultural conditions in the local context, we recommend that future research conducted in various other contexts will allow for generalizations as well as cultural comparisons that would enrich our understanding of the extrinsic factors influencing the relationship between students' self-views and career aspirations.

Another limitation in this research project is associated with the methodology of this research. More specifically, the theoretical framework adjusted for this research project constrained the possibility to develop a deep connection with students' social positioning and how this might have influenced their self-views and career aspirations.

In this research project, and particularly in the study presented in Chapter 4, we used a collection of case studies to make assertions on how the students view themselves in relation to science and relevant career aspirations. In so doing, we used an adjusted version of SCCT model with a focus on the dimensions related to personal traits and abilities, experiences in the family and school environment as well as in the social context, self-efficacy issues and outcome expectations, interests, goals, actions, and career aspirations. As Merriam (1998, p. 29) argues, by adopting a case study approach, we aimed "to uncover the interaction of significant factors" that characterize the case. Hence, we did not explore how students' self-view in relation to science interacts with various other identities (i.e., gender, ethnicity, religion, race, and migration background) and the ways in which this interplay influences their career aspirations since such dimensions were not deemed critical for the purpose of this study, considering the country context. For example, we did not explicitly address how gender influences students' self-view and career aspirations (despite our findings on differences between female and male students), since EU statistics show that in Cyprus there is a non-significant gender gap in employment (9.4%) (EC, 2017). We consider that the country context reflects a more collectivist or family-centered culture and so, we mainly focused on the social aspect (i.e., social environment, school and family).

Furthermore, the purpose of the study was not to identify differences within the sample, hence we chose a homogeneous group of students in terms of socio-economic status and cultural experiences that we followed over a period of time. The use of the qualitative case study approach enhanced the explanatory power of our analysis and illuminated our understanding of students' behavioural and thinking patterns in terms of their self-views in relation to science and their career aspirations. Hence, this approach served its heuristic purpose by confirming what is known (e.g., the strong role of family members), extending our experience, and finally providing insights that help structure future research (Merriam, 1998).

Last, it is worth noting that I acknowledge my personal bias and interest in this project as an insider of the context, and also the main researcher in terms of research design, data collection, and analysis. To address this issue, triangulation was achieved through the collection and analysis of data from various sources (i.e., student questionnaires and teachers' interviews), and to ensure trustworthiness, a second rater was involved in data analysis who independently coded a random 20% of the qualitative data set which we then discussed until we reached consensus (Merriam, 2009).

6.4. CONTRIBUTION

The findings that emerged from this research add to the existing literature in different ways as discussed below.

6.4.1. STEM curriculum materials

First, we provide a free, concrete set of STEM curriculum materials that informs the design of career-oriented curriculum and instruction aiming to enhance students' interest in science and understandings of STEM careers.

The STEM curriculum materials, referred to as 'career-based' scenarios, are stories related to socio-scientific issues (e.g., climate change, energy, public health) that create the need for connecting with a STEM expert (e.g., energy efficiency consultant). These stories are framed within a personally relevant context, a prevalent feature of the scenarios, which is linked to students' everyday life, school, and community. The main features of the scenarios include a personally-relevant content (e.g., real-life and contemporary socio-scientific issues), tasks promoting participation (e.g., a mission), collaborative group-work, references to STEM careers, and interaction with experts in STEM fields. It is important to note that in designing these scenarios, we paid attention to how they can be integrated into science teaching units that were already established in the curriculum in close collaboration with the science teachers.

In this research project, we presented eight career-based scenarios (Chapter 2) that were implemented in science classrooms. The example below provides a brief description of what a career-based scenario is:

'Save the polar bears' scenario focuses on climate change as a critical issue of global concern. It was implemented in the teaching unit of 'heat transfer' to provide 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. In this scenario, 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.

It is worth noting, that career-related goals and interaction with experts from STEM fields are currently missing in the national curriculum. Hence, the integration of career-based scenarios in science teaching units is considered to be an innovation for the science curriculum in the country context because of their content and the involvement of experts.

6.4.2. Empirical evidence that satisfies the need for career education

Second, we provide empirical evidence that sheds light on the intricacies of designing and enacting career-oriented teaching innovations focusing on the ways in which such curricula innovations can potentially enhance students' interest in science and STEM careers.

According to research studies, young people lack awareness about STEM careers which hinders the formation of STEM career aspirations (e.g., Blotnicky et al., 2018). At the same time, research evidence indicates that many initiatives in science education aiming to broaden participation in STEM fields had a non-significant impact on students' career aspirations since they were perceived as short-term, fragmented and stand-alone interventions isolated from school curricula. More specifically, such studies indicated that career-oriented initiatives had a minimal contribution from industry representatives in promoting career awareness or aspirations (e.g., Kudenko et al., 2017) and that despite broadening students' understanding of science jobs, they did not change significantly their personal aspirations or views of science (e.g., Archer et al., 2014).

In the research project reported in this thesis, we provided empirical evidence indicating two important parameters to be taken into account when designing career-oriented teaching innovations: (a) to create opportunities for students to interact with practising scientists and, (b) to provide connections between STEM careers and curricular topics. These findings provide insights to studies pointing to the need for infusing career-related instruction through carefully designed STEM engagements with the potential to empower students in making informed career decisions (e.g., Reiss & Mujtaba, 2017).

6.4.3. Designing and enacting career-oriented curriculum materials

Third, this research also provides support to educators and instructional designers focusing on how to design and implement career-oriented materials (Chapter 2). Reflecting on our experiences, we describe this process in two phases as follows:

Phase 1: Design of career-based scenarios

Step 1. We developed the career-based scenarios based on a set of design principles (common features as described in 5.4.1. above). Examples of these features are the following: personally-relevant topic and context; problem-based activities; interaction with experts; ICT tools; group work; reflection activities.

Step 2. We worked with the teachers to identify the teaching units in the science curriculum that could host the scenarios, as well as the STEM-related careers and experts that would act as role models. Considering the 'genius scientist' stereotype, we were careful to work with possibilities to challenge this view and also to address gender stereotypes in relation to STEM careers.

Step 3. We developed the scenario in the context of a topical socio-scientific issue with global relevance and local implications in order to make explicit connections with students' everyday lives and the public discourse that was accessible to them. Then, we looked through established teaching units to explore how the scenario could fit within the existing school curriculum 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 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.

Phase 2: Scenario implementation

The implementation session of the scenario was structured as follows: introductory scenario presentation and its connections to the teaching unit (e.g., a discussion focused on the socio-scientific issue to establish a link to the teaching concept), follow-up activities (e.g., experimentation) 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 (e.g., experts' visit, more experimentation, reflective discussion).

6.4.4. The longitudinal aspect

Another significant facet of this research associates with the longitudinal aspect embraced within the case study approach. In order to gain an in-depth understanding of a situation then one should consider as many variables as possible and their interaction over a period of time (Merriam, 1998). To achieve this, the classroom-based study reported in this thesis, offered a detailed description of the integration and enactment of career-based scenarios in science class over a two-year period. This iterative process provided insights that inform the design and implementation of curricular innovations targeting students' interest and understandings of STEM careers responding thus to the call for more pedagogical efforts towards this end (e.g., Potvin and Hasni, 2014). Similarly, the findings from the five-year exploration of students' self-views in relation to science add to the existing body of literature and contribute towards closing the gap in the knowledge base regarding the factors influencing students' goal setting during the transition from compulsory to post-compulsory education (Reinhold et al., 2018).

6.4.5. SCCT model as a theoretical and analytical framework

The original version of the SCCT model has been used to frame studies that aimed to understand how people develop interest and make career-related choices and actions considering the interaction between personal dynamic aspects and the surrounding social and family environment. Given the personal dynamic aspects, the construct of 'self-concept' or 'self-view', which is dynamically formed via inner processes in a social context (Hattie, 2008), has been considered fundamental for understanding career aspirations and choice (Rüschenpöhler & Markic, 2019). In order to investigate the interplay between interest and self-view and understand the ways in which secondary school students form their study and career aspirations in relation to science (or not), an adapted version of the SCCT model was needed using an umbrella concept of 'self-view' for the dimensions of interests, goals and actions. As evidenced particularly in the fourth study of this these, from a theoretical and analytical perspective, the use of the adjusted version of SCCT model served to enrich our understanding of how secondary school students' behavioural and thinking patterns evolve between ages 13 and 17, in terms of their self-view in relation to science, based on the three dimensions: (a) a broader interest in science and tenacity in a science discipline (interest variable); (b) an intention to choose and pursue STEM studies and (goal variable), and (c) actions towards the realization of the set goals (action variable).

The integration of the concept of 'students' self-view' in SCCT model facilitated the development of students' profiles revealing a diversity in the evolution of student self-views in relation to science and also the dynamic interplay between the students' self-views and career aspirations (STEM-related or not) through the secondary school years in the light of intrinsic and extrinsic influencing factors (i.e., personal passion, family science capital, outcome expectations, educational experience, and self-efficacy, as well as science/technology-related hobbies). Nevertheless, given the 'locality' of the study and therefore the homogeneity of the sample with respect to socio-economic status and societal culture, this research did not focus on how 'person inputs' related to race, ethnicity and diverse social class might influence the interplay between students' self-views in relation to science and career aspirations. Hence, in efforts to develop a more comprehensive understanding of the relationship between self-view and career aspirations in other contexts, a combination of the SCCT model with the adoption of a theoretical paradigm in intersectionality can provide theoretical extensions on students' development of a self-view in relation to science and related career orientation considering various other identities.

6.5. IMPLICATIONS FOR THEORY

In this thesis, we discussed the different studies in relation to the existing literature. Although the limited sample size and the 'locality' of this study, we argue that the outcomes of this research have important implications for theory connected to the development of interest in science, students' understandings of STEM careers, and their perceptions of self in relation to science.

As documented in this research project, the findings confirm a shift from conventional approaches for teaching in science towards more contextualized interventions aimed to enhance interest in science (e.g., Potvin & Hasni, 2014). More specifically, they do suggest that novelty (e.g., interactions with experts in informal settings, the use of scientific tools and related software) serves the purpose of triggering and/or sustaining SI. The findings also illustrated that students' SI was (re)activated through their involvement in scientific practices (i.e., problem-based activities, lab experiments, modelling, and poster design), especially when these were presented as new instructional events. This confirms previous studies suggesting that SI can be triggered through repeated arousal (e.g., Rotgans & Schmidt, 2017). In addition, we found that students' interest in the scenario-related activities stems from a combination of being interested in the activity, the content, and the extent to which the level of difficulty corresponds with students' self-efficacy beliefs as also suggested by Habig et al. (2018). Collaborative group-work and learning important information about global socio-scientific issues and careers were also indicated to facilitate triggering and even maintaining students' SI. These findings provide insights that could be used to further theorise about the development of interest in science in terms of the sources of situational interest.

Furthermore, the findings from the implementation of career-based scenarios demonstrated that providing connections between theory and practice and career in science class can enhance students' understandings of STEM careers. We found that the students developed comprehensive understandings of the experts' background, skills, and tasks in relation to the science concepts introduced in each scenario, particularly when they interacted with them. Reflecting on this finding, we recommend inducing career-related information in science class reinforcing Reiss and Mujtaba's (2017) suggestion to embed career education in STEM lessons, but at the same time, we suggest doing it in personally relevant and meaningful ways (e.g., interaction with experts). These insights would be particularly useful in designing informal learning environments (e.g., science centres) promoting fruitful collaborations with industry partners thus scaffolding young people's engagement in authentic STEM-related workplace environments.

Considering the theoretical construct of self-view in relation to science, we found that the use of the adjusted version of SCCT model with a focus on the dimensions of interest, goals, actions, and the contextual affordances (i.e., social context and family and school environment), and also the longitudinal qualitative data served to enrich our understanding of secondary school students' behavioural and thinking patterns with respect to their career aspirations. These findings add to the existing body of literature and contribute towards closing the gap in the knowledge base regarding the factors influencing students' goal setting during the transition from compulsory to post-compulsory education (between ages 13 and 17) (Reinhold et al., 2018). Nevertheless, our findings do not provide insights into how various other identities that are central social positioning (e.g., ethnic identity, race identity, gender identity, migration background, social class) may influence students' self-view and the formation of relevant career aspirations (Avraamidou, 2019). Hence, we identify the need for a more comprehensive understanding of the relationship between self-view and career aspirations by adopting a theoretical paradigm in intersectionality that considers various identities to further theorize about students' development of a self-view in relation to science and related career orientation.

6.6. IMPLICATIONS FOR RESEARCH

First, we provide a summary of the findings with respect to the three research purposes of this project.

In responding to the need for infusing career-related information in the science curriculum (e.g., Reiss & Mujtaba, 2017), the first research purpose of this project addressed the design and implementation of career-oriented teaching innovations in science class. We provided a concrete set of curriculum materials, referred to as career-based scenarios, with the potential to enhance students' interest in science and understandings of STEM careers. The scenarios were designed to be integrated into already established science teaching units and adhere to certain design principles so as to be interesting and personally relevant to students.

The second research purpose was to explore the impact of career-based scenarios on students' interest in science and their understandings of STEM careers. The findings demonstrated that the scenario features that could possibly trigger students' SI and enhance their understandings of STEM careers are: (a) promoting students' active engagement through a problem-based approach that incorporates novel scientific practices; (b) establishing connections between classroom discourse and authentic workplace environments by transferring science concepts to a real-life-personally-relevant context; and (c) integrating the STEM career component through informal interactions with experts.

The third research purpose focused on exploring students' self-views and career aspirations in relation to science and the evolution of the latter through the secondary school years. The findings indicated a dynamic relationship between students' self-views and career aspirations that is influenced by experiences with school science, and also extrinsic factors related to the social context and family environments. More specifically, gender differences, family backgrounds and expectations, engagement with science-related activities, and interest in science were found to have a critical role in shaping students' self-views, and also their career aspirations. The findings revealed that career aspirations changed differently with time and were associated with educational experiences, changes in self-efficacy beliefs, extra-curricular interests and hobbies.

Considering the implications of the classroom-based study from a research perspective, it would be interesting for future research to answer the following question: What is the impact of long-term career-oriented instruction on students' career aspirations? Provided that the process of forming career aspirations can be predicted to a great extent by students' self-concept which remains relatively stable after primary school (Rüschenpöhler & Markic, 2019), we recommend future interventions targeting younger students that start early in primary school classes and continue through the secondary school. Such studies though need to also consider the connection with the formative processes that shape students' self-views outside the school context.

Moreover, it would be also useful to continue these longitudinal efforts and further explore students' trajectories from the secondary school until they enter the job market. Findings from studies that cover the wide spectrum of school life from primary through tertiary education would provide insights to fully understand the evolutionary relationship between students' self-views and career choices. These findings would be particularly helpful to provide recommendations for curriculum design in learning settings with the potential to facilitate students' identification with science.

It would also be worthwhile to investigate the teacher's role in this aspect. As Christidou (2011) claims, the teacher's role is an important factor in determining students' views. We argue that providing teacher professional development can usefully aim to improve understandings of the range of options and diversity in STEM careers and how to incorporate that into teaching practices. In this view, it would be useful to answer questions such as: How does the teacher interact with the career-based scenarios? How does the teacher make connections between theory and authentic work using career-based scenarios? In what ways can we support the teacher to maximize students' engagement in career-oriented learning activities?

Another interesting line of research would be to investigate the impact of such career-oriented interventions on larger samples of students and in a variety of social and cultural contexts. Future research beyond geographical borders would be useful for cross-cultural comparisons that might inform the theoretical and empirical underpinnings in terms of the development of interest in science learning environments. For instance, gender was not an explicit dimension of the classroom-based study in this project given the low scores of the country in terms of gender stereotypes. However, statistics indicate that women are under-represented in STEM fields (OECD, 2020) reflecting the stereotype reflects the stereotype that STEM fields demand time and commitment, which makes it difficult for a woman to combine both being a STEM professional and a mother. Empirical studies point to the need for providing female students of color with opportunities to engage with science in formal and informal schooling (e.g., Bindis, 2019; Kang et al., 2018; King & Pringle, 2019). Hence, career-oriented interventions in contexts with gender differences could respond to questions such as: In what ways does career-oriented instruction in science classrooms: (a) enhance female students' interest in science, and (b) impact female students' STEM career aspirations?

Furthermore, in this project, we solely focused on learning experiences and extrinsic factors related to the social context and the family environment that influence students' self-views in relation to science. Another interesting area of research would be to explore students' self-views and career aspirations with a focus on factors related to social positioning (i.e., gender, religion, race, migration background, social class). According to research evidence, STEM career aspirations were found to be gendered and also racialized (DeWitt & Archer, 2015). In attempting to explore young people's self-views in relation to science, we need to address such inequalities and understand why these might influence science participation and how this intertwines with the formation of STEM career aspirations (Avraamidou, 2019). For example, important gender-related questions might arise at a personal, cultural, and institutional level, such as: How did your science-related experiences differ from those of your male classmates? How does your sense of self as a female influence your participation in science? How does your family see you? How does your teacher see you? In what ways does race influence students' self-views in relation to science and career aspirations? A similar set of questions can be linked to social class and religion. Further research to answer similar questions appears critical in understanding the ways in which young people see themselves in relation to science, make educational choices, and form relevant career aspirations in efforts to increase the numbers of females and historically underrepresented racial groups in STEM fields.

6.7. IMPLICATIONS FOR PRACTICE

The outcomes of this research project have implications for practice associated with the design, implementation, and evaluation of science education interventions that suggest reform recommendations. Primarily, we provide an evidence-based set of curriculum materials that highlights the importance of framing science instruction within a real-life personally-relevant context, suggesting informal interactions with STEM professionals. Drawn from the findings of the study, we recommend that the integration of such career-oriented materials in science curriculums have the potential to reconstruct students' stereotypical views of scientists and develop positive attitudes towards science and STEM careers. As evidenced in this project, the development of a friendly and informal environment during the experts' visits minimized the risk of positioning the expert as a 'genius' scientist. However, it was also indicated that the adoption of a lecture-type presentation from the experts can have a negative impact on students' interest. Hence, we found that such visits must occur in close collaboration with the teachers in order to be meaningful and interesting. This kind of collaboration has the potential to support interactions with the experts on a more personal level which in turn has the potential to support students in deconstructing existing stereotypes about the work of scientists as well as them as persons. We acknowledge that not all students will aspire to pursue STEM careers, but we hope that such career-oriented instruction will inspire a greater number of young people of different cultural backgrounds to follow these paths achieving a better representation of women and minoritized populations. Hence, it appears critical to infuse career-related information in early school science classrooms and provide opportunities to interact with STEM experts of diverse cultural backgrounds and social positioning in order to develop an understanding of the diversity of STEM careers and who can be a scientist, become aware of STEM career options, and at the same time explore connections with themselves regardless of external influences (e.g., Drymiotou et al., 2021a; Blotnicky et al., 2018; Reiss & Mujtaba, 2017).

We provide a concrete example of a career-oriented intervention with a detailed description of the design, development, implementation, and evaluation of curriculum materials to support students' development of interest in science and understandings of STEM careers. This set of findings can support K-18 educators in how to adjust and incorporate career-oriented materials into educational practice thus facilitating students' self-identification with science and STEM career options.

It would be also of great interest to use these findings as input in professional development programmes for instructional designers and educators in formal and informal science learning environments. For example, these findings could inform the design and evaluation of exhibits in informal science institutions with the potential to promote fruitful collaborations with industry partners and engage young people in authentic STEM-related workplace environments.

Reflecting on the findings of this research project, we conclude with an indicative set of design principles for career-oriented curriculum materials. These design principles could inform the design of such teaching innovations with the potential to support students' interest in science and facilitate their identification with science and STEM career options. This set of design principles is summarized below:

- The curriculum materials need to have clear connections to the already established teaching units in the science curriculum in terms of content (e.g., a scenario focused on climate change that could be integrated into the teaching unit of 'heat transfer').
- The curriculum materials need to be framed within a personally-relevant context (i.e., references to authentic and real-life scientific issues) to facilitate knowledge acquisition related to global socio-scientific issues and careers. This can be achieved when transferring science concepts to a real-life-personally-relevant context thus establishing connections between theory and practice.
- The content of the curriculum materials needs to be interesting and personally relevant to the students (e.g., references to people who can act as role models).
- The curriculum materials need to include collaborative activities and promote students' engagement in scientific practices (e.g., lab experiments, modeling). This can be facilitated through problem-based activities in the form of a mission which also helps in establishing connections between theory and practice.
- The curriculum materials need to promote personal interactions with STEM experts from different cultural backgrounds and social positioning. The teacher needs to collaborate with the expert to carefully plan the visit ahead of time and set the ground. Informal discussions and a casual outfit of the expert(s) facilitate the development of a connection with the students and perhaps the reconstruction of stereotypical ideas about scientists.
- Combined with other features (e.g., interaction with experts), the curriculum materials need to integrate engaging media (e.g., ICT tools) in order to: present the content, prompt discussion, establish a link between its content and the curriculum.

6.8. ON A FINAL NOTE

To conclude, this research project provides empirical evidence indicating that infusing career-related information in science curriculums framed within a personally-relevant context can enhance students' interest in science and understandings in STEM careers. However, the findings also revealed that this two-year career-oriented intervention did not result in more students interested in exploring the possibility of pursuing a STEM career. Through analysis of the qualitative data collected over a five-year period, it was indicated that non-school related factors come into play that influence students' self-view in relation to science which predicts career aspirations to a great extent. These are associated with the longitudinal impact of social context and environment considering family influences and the science capital, gender differences in terms of outcome expectations and different values, and the opportunities to engage with science-related activities in formal and informal settings. Future research in various other contexts with larger samples can provide recommendations for curriculum design at an international level with the potential to facilitate students' self-identification with science and STEM career options.