ANSSI SALONEN

Scientific careers attract few students. This dissertation presents a design-based research to develop career-related science education. Students’ career awareness and co-designing science education with various stakeholders are investigated. Research contribution delivers a model of career-related instruction promoting career awareness and the attractiveness of science. This instructional framework can be implemented in science education but also in different subjects and fields of education.
CAREER-RELATED SCIENCE EDUCATION

INSTRUCTIONAL FRAMEWORK PROMOTING STUDENTS’ SCIENTIFIC CAREER AWARENESS AND THE ATTRACTIVENESS OF SCIENCE STUDIES AND CAREERS
Anssi Salonen

CAREER-RELATED SCIENCE EDUCATION
INSTRUCTIONAL FRAMEWORK PROMOTING STUDENTS' SCIENTIFIC CAREER AWARENESS AND THE ATTRACTIVENESS OF SCIENCE STUDIES AND CAREERS

Publications of the University of Eastern Finland
Dissertations in Education, Humanities, and Theology
No 153

University of Eastern Finland
Joensuu
2020
ABSTRACT

The negative trend and the challenge of students not choosing science studies and particularly scientific careers has been recognised widely in the Western world according to research papers and PISA reports. The problem is particularly real in Finland where high achievers in science do not pursue careers in science. Previous research shows that students are not well aware of science-related careers and the related skills and competences. During few recent decades science education research has provided suitable teaching and learning approaches to raise the attractiveness of science, for example by introducing real life contexts in science. However, these approaches rarely discuss the careers behind the scientific work.

This dissertation approaches the challenge from the perspective of students’ low career awareness of scientific careers by presenting design-based research developing an instructional framework model of career-related instruction in science education. Therefore, the overall aim of this dissertation is to find out how career-related instruction including career-based scenarios affects students’ career awareness and science attractiveness. In addition, role of the teachers as educational designers is examined to illustrate a whole picture of different stakeholders’ perceptions about the instructional innovation developed through design-based research (DBR). With these aims three original empirical studies were conducted during 2015-2019.

In the first study students’ perceptions of working life skills in science-related careers were asked with a questionnaire and analysed by content analysis. This study providing interesting and important background for further research revealed that students’ knowledge of working life skills was extensive and wide. However, in a larger scale their perceptions were stereotyped, particularly with careers working in specific scientific fields and science topics. After exploring and analysing the literature and the background studies such as the study I, the DBR continued with school interventions. Students participated in these interventions designed and implemented by their teachers.

The second study presents in detail one of the four interventions promoting students’ career awareness and interest towards science learning. Data was gathered by observing intervention lessons, students’ intervention evaluation questionnaire and teachers’ planning meeting audio-records which are complemented with notes from discussions between teachers and researcher during the intervention. The results reveal that students were eager to learn new knowledge and they were interested to
participate in the learning activities. They perceived the topic and problem described in the intervention important for the world but not for them. These findings indicated an important challenge that had to be addressed during the next interventions and in the development of career-related instruction.

In the third study, the focus was on teachers’ perceptions about co-designing career-related instruction. Discussions and interviews with teachers indicate that teachers’ ownership and agency play a crucial role in designing and implementing novel instructional designs successfully. According to the findings, teachers’ support for the design, their need for change, level of autonomy and accommodation are important factors for co-designing processes. In addition, the third study indicates a positive sign on the success of the developmental work as students’ interest and career aspirations were increasing as the design-based research proceeded.

Local and global challenges lie ahead, and science education is in a key role to encourage and attract young individuals to face and overcome these challenges through science. The developed research-based instructional framework for career-related instruction helps educators in different locations and contexts around the world to recognize the practicality and necessity of introducing and handling careers in science education to promote students’ science study and career aspirations.

**Keywords:** science education, career awareness, science attractiveness, instructional designing, design-based research
Salonen, Anssi
Ammatteihin perustuva luonnontieteiden opetus. Tietoisuuden luonnontieteellisistä ammateista sekä luonnontieteiden opiskelun ja uran houkuttelevuuden lisääminen opetuksessa.
Itä-Suomen yliopisto, 2020, 65 sivua
Publications of the University of Eastern Finland
Dissertations in Education, Humanities, and Theology; 153
ISBN: 978-952-61-3372-0 (nid.)
ISSNL: 1798-5625
ISSN: 1798-5625
ISBN: 978-952-61-3373-7 (PDF)
ISSNL: 1798-5625
ISSN: 1798-5633

TIIVISTELMÄ


Toinen osatutkimus esittelee yksityiskohtaisesti yhden neljästä interventiosta, joita tarkoituksena on oppilaiden ammattitietämyksen ja kiinnostuksen lisääminen luonnontieteiden opiskeluun. Aineisto on kerätty observaamalla intervention opittunteja, intervention arviointilomakkeilla oppilaita ja opettajien suunnittelupalaverin

Kolmas osatutkimus keskittyi opettajien käsityksiin ammatteihin perustuvan opetuksen yhteissuunnittelusta. Opettajien kanssa käydyt keskustelut ja haastattelut osoittavat, että opettajien omistajuus ja toimijuus ovat merkittävissä roolissa uusien opetustapojen suunnittelussa ja toteutuksessa. Tulosten mukaan tärkeitä tekijöitä yhteissuunnitteluprosessin onnistumiselle ovat opettajien tuki ja kannatus, koettu muutostarve, riittävä autonomia sekä heidän mukautumiskykyynsä. Lisäksi kolmas osatutkimus osoittaa positiivisia merkkejä design-tutkimuksen kehitystyön onnistumisesta sillä oppilaiden kiinnostus ja uratoiveet lisääntyivät design-tutkimuksen edetessä.

Edessämme on paikallisia ja globaaleja haasteita. Luonnontieteiden opetuksella on ratkaiseva rooli kannustamalla ja houkuttelemaa nuoria kohtaamaan ja ratkaisemaan näitä haasteita luonnontieteiden avulla. Tutkimusperustaisesti kehitetty ammatteihin perustuva opetus auttaa kasvatus- ja opetusalan ammattilaisia eri paikoissa ja tilanteissa huomaamaan ammattien käsittelevä käytännöllisyyden ja tärkeyden opiskelijoiden luonnontieteellisten opiskelu- ja uratoiveiden edistämisessä.

Avainsanat: luonnontieteiden opetus, ammattitietoisuus, luonnontieteiden houkuttelevuus, opetuksen suunnittelu, design-tutkimus
ACKNOWLEDGEMENTS

To be honest, I am quite confused and surprised to finally write these acknowledgements. I have always loved trips and journeys as much as arriving in final destinations. Now it feels like an end of a journey but at the same time I am arriving to a very interesting place. I do not want this journey full of experiences to end but still I want to enjoy the moment of arrival before navigating towards next destinations. Along this journey, I have met incredible people who have supported and guided me on the way to finish this dissertation. Therefore, I would like to express my gratitude to those important and special people for their encouragement, collaboration and partnership on this journey.

First of all, I would like to express my sincere gratitude to my main supervisor Professor Tuula Keinonen for all the continuous support, advice and calm attitude I have received ever since I met her in research seminar for candidate thesis in 2011. She has involved me in various research projects and in 2015 I had the opportunity to join the EU Horizon 2020 funded MultiCO research team which she coordinated. Under her supervision and through our mutual trust to each other, I have learned and achieved so much about academic community and research. I can only hope that someday I can pass on the knowledge and skills I have gained.

I also want to acknowledge my co-supervisors Dr. Sirpa Kärkkäinen and Dr. Anu Hartikainen-Ahia. Their constructive criticism and encouragement through difficult and exhausting phases of the process has helped me to gain more understanding of research, and particularly of methodology. Somehow, they were able to sense how I was coping and set the standards high enough for the emerged situations.

I warmly thank the preliminary examiners of my manuscript. Professor Silvija Markic from the Ludwigsburg University of Education and Anna Uitto from the University of Helsinki had the time to focus on my dissertation. I appreciate their valuable and refining comments.

I have already mentioned the MultiCO project, but I wish to thank all the national and international members for all the co-development and collaboration professionally, socially and personally. Dr. Jingoo Kang, Dr. Lara Weiser, Ilpo Jäppinen and Katri Varis were always there if I needed help with research, language or just to keep on going. MultiCO project also introduced me to Professor Annette Scheersoi and Professor Shirley Simon. With both of them I have had inspiring and creative discussions about science education and research. Once again, thank you MultiCO team.

My journey into academic community started in Joensuu and I am grateful for the support of those former fellow university students who became close friends to me. Early in the studies they gave me a nickname “doctor”. No one probably remembers the origin of the nickname anymore, but it seems that “Nomen est omen”. I also thank Dr. Kari Sormunen for keeping my nickname in life but also for his support through master’s degree programme and raising my interest in science education.

After my master’s degree studies, I met Dr. Ask Heinonen, Dr. Jani Kaasinen and Tuomas Olli, first as my mentors in technology education but later as colleagues when I started as a university teacher. They encouraged me to continue in my academic career. For few past years my closest colleagues Antti Jouppi, Ossi Ruotsalainen, Dr. Henriikka Vartiainen and other craft science teaching and research staff have listened
to me, laughed with me, and been creative and flexible to make it practically possible for me to finish this dissertation.

Last, but not least, I would like to thank the people closest to me. I am grateful for my parents and sister for their interest and support in my career and life. Finally, I want to express my eternal gratitude with love to my dear wife Niina. Without you and your unconditional and unlimited understanding, love, sacrifice, advices and support, this and other journeys in our life would have been impossible and meaningless.

Joensuu, March 2020
Anssi Salonen
LIST OF ORIGINAL PUBLICATIONS

This dissertation is based on the following original publications:


The author of this dissertation was the main and corresponding author in all three studies and have been in charge of planning and designing data collection, analysing the data and reporting the results. Planning and designing data collection have included national and international collaboration in all three studies.
# TABLE OF CONTENTS

ABSTRACT ................................................................................................................. 5
TIIVISTELMÄ ............................................................................................................. 7
ACKNOWLEDGEMENTS ......................................................................................... 9

1 INTRODUCTION ................................................................................................. 17

2 THEORETICAL FRAMEWORK ......................................................................... 19
  2.1 Students’ career awareness ......................................................................... 19
  2.1.1 Science-related careers ....................................................................... 19
  2.1.2 Working life skills related with 21st century skills ................................ 20
  2.2 Science education through career contexts ................................................. 22
     2.2.1 Students’ interest, relevance and career aspirations in science ......... 23
     2.2.2 Context-based learning .................................................................... 24
     2.2.3 Career-based scenarios in science teaching .................................... 25
  2.3 Co-designing science education .................................................................. 26
     2.3.1 Teacher professional development through collaboration ............... 26
     2.3.2 Teachers’ ownership and agency in educational co-designing ......... 27
  2.4 Summary of the theoretical framework ....................................................... 29

3 AIMS OF THE RESEARCH .................................................................................. 30

4 METHODS ............................................................................................................ 32
  4.1 Pragmatism as philosophical background .................................................. 32
  4.2 Mixed methods .............................................................................................. 33
  4.3 Design-based research .................................................................................. 33
  4.4 Participants .................................................................................................... 35
  4.5 Data collection and analysis ......................................................................... 35
  4.6 Quality and ethics of research ...................................................................... 38

5 RESEARCH CONTRIBUTION ............................................................................. 40
  5.1 Background: Students’ perceptions of working life skills (Study I) ........... 40
  5.2 First intervention: Old pipes found .............................................................. 42
  5.3 Second intervention: Water (Study II) ......................................................... 44
  5.4 Third intervention: Coal to teeth (Study III) ............................................... 47
  5.5 Fourth intervention: Blackout ...................................................................... 49

6 PERSPECTIVES ON CAREER-RELATED INSTRUCTION .................................. 51
  6.1 Need for change ............................................................................................ 51
  6.2 Career-related instruction ............................................................................ 52
     6.2.1 Design principles and practical prerequisites .................................... 53
     6.2.2 Career-based scenario and other learning experiences ..................... 54
     6.2.3 Learning, attitudinal and career aspiration outcomes ....................... 55
  6.3 Implications and suggestions for future directions ....................................... 55

REFERENCES ............................................................................................................. 57

ORIGINAL PUBLICATIONS (I – III) .......................................................................... 65
LIST OF TABLES

Table 1. The deductive approach to form categories of ownership and agency in study III. ................................................................. 28
Table 2. Data collection and analysis.................................................................................................................. 36
Table 3. Categorisation of working life skills the students mentioned................. 41
Table 4. Design hypotheses and instruction design in the first intervention .... 43
Table 5. Design hypotheses and instruction design in the second intervention......................................................................................... 44
Table 6. Categorization of observations in study II .................................................. 45
Table 7. The results of the instruction unit evaluation in study II. N=39.............. 46
Table 8. Design hypotheses and instruction design in the third intervention ... 47
Table 9. Categorization of teachers’ perceptions about the instruction in the light of ownership and agency................................................. 48
Table 10. Students’ scenario evaluation descriptive statistics. N=41.................. 48
Table 11. Design hypotheses and instruction design in the fourth intervention......................................................................................... 49
Table 12. Students’ scenario evaluation descriptive statistics. N=36................. 50
LIST OF FIGURES

Figure 1. Summary of the theoretical framework, key concepts and their relations in this dissertation .............................................................. 29
Figure 2. Overall aim of the dissertation and sub-study research questions .... 31
Figure 3. The generic model of the DBR conducted in this dissertation (cf. McKenney & Reeves, 2019) ........................................................ 34
Figure 4. Content analysis in study I ......................................................... 37
Figure 5. Students’ perceptions of the required working life skills in science-related careers ................................................................. 42
Figure 6. Career-related instruction model in science education ................. 53
1 INTRODUCTION

Few past decades have introduced us with major global challenges related with science such as clean food and water, sufficient energy, sustainability, climate change and technologization. More dramatic is that we lack students choosing to study and work in science to solve these challenges (Bøe et al., 2011; OECD, 2016). Furthermore, to overcome these challenges, we need not only professional scientists, but also scientifically literate decisionmakers, citizens and other social actors, who have accurate information about the Nature of Science, scientific careers and the required skills in these careers. Students’ low aspirations towards scientific careers has been acknowledged for decades and received a lot of attention in science education research. However, changes have remained scattered and local. To accomplish a change, we need to first identify the reasons why students are not pursuing studies and careers in science. High achieving students in science do not pursue studies and careers in science, because they lose their interest during their school years (Krapp & Prenzel, 2011; Osborne & Dillon, 2008). When compared with the trend in students’ decreasing interest in science and science careers, particularly in Finland (OECD, 2016), it seems that science education fails to maintain top achievers in science. Low interest and perceived relevance together with ignorance of Nature of Science and scientific careers leads to students being reluctant of choosing studies and careers in science (Maltese & Tai, 2011; Masnick et al., 2010).

Providing students with wide-ranging awareness of careers and working life skills in scientific careers helps the students to recognize their own capabilities in science and hence raise their interest in science. Unfortunately, educators and researchers, such as I, has struggled to find suitable ways to introduce careers and work life as part of science education. Therefore, students are not introduced with authentic work life of scientific careers and school activities often might promote stereotypical images of these careers. Thus, science education and the pedagogical methods might have a key role to promote science careers and increase students’ interest and career awareness in science. To do so, research in science education has already developed working teaching strategies that can be utilized. Latest major educational design is learning science through contexts of science. This context-based approach results in students’ increased attitudes towards science (Bennett, Lubben & Hogarth, 2007). In addition, using Socio-Scientific Issues (SSI) have been proposed and seen attracting students to study science (Sadler, 2011). This research approaches teaching in science education to inspire and promote students’ interest towards science by making science more relevant and exciting. In addition, improve their awareness of scientific career options and why studying science is important. Attractive science teaching is a part of making all future citizens interested of making choices based on scientific, technology and environment knowledge.

Since you read this far, you must be wondering why I got interested about science education research and particularly studying the use of science-related careers in science education. Then you need to hear my “career story” first. I can recall that my first dream job was to be a LEGO engineer. Later in primary school I realized that this isn’t probably a realistic option. However, I got interested in science and enjoyed learning mathematics and science through primary and high school. In high school I decided to pursue a career in dentistry or computational engineering. I ended up
studying the latter for one year. I realized that my motivation in mathematics was not enough to compensate my interest in computers and electronics. Next spring, I decided to apply to dental studies once more but also to physics and educational sciences as a backup plan. In Fall 2008 I found myself studying physics in the former University of Joensuu, but I struggled to see my future career in physics. During the next two years I applied to paramedic and nurse schools, civil engineer studies and primary school teacher education. In 2010, I was selected to nurse school but also to educational sciences, more precisely to study to become a primary school teacher.

During the years in education science studies I understood how stereotypical my previous career aspirations were. I realized that there are more diverse science-related careers than just medical professions, engineers or physicists. Too little, too late for me, but my curiosity had awakened towards science education and what might have influenced on my previous career choices. In my Master’s Thesis I studied pre-service science teachers’ narratives and what affected their study choices. Finally, in this dissertation, I can study how to increase students’ interest in science and how to help them to acquire awareness of the huge variety of different science-related careers early enough.

This dissertation is conducted as part of European Union Horizon 2020 project MultiCO (https://multico-project.eu), in which I worked as a researcher for 3 years. In this dissertation, I study the students’ perceptions of working life skills in science-related careers and are the students’ truly unaware of science-related careers. Moreover, what kind of instructional model can be developed through design-based research (DBR) to combine the best out of previous educational approaches in science and a novel idea of including careers and working life into science education through educational innovation called career-based scenarios?

The goal of DBR is to build links between educational research and practice (Amiel & Reeves, 2008). The process itself starts with analysing a problem and continues with creating, evaluating and refining interventions. Therefore, in Chapter 2, I describe the theoretical foundation for this dissertation. After summarising the theoretical framework, aims and methods of the research are described in Chapters 3 and 4. The results of the original three studies are presented in Chapter 5. These studies are supplemented with research contribution of two interventions carried out and reported in the MultiCO project deliverables by the author of this dissertation (Simon et al., 2016; Simon et al., 2018). Finally, Chapter 6 sums and concludes the results briefly and offers discussion about the educational implication of career-related instruction. In addition, the final chapter acknowledge the limitations of the dissertation and offers future research suggestions of what the DBR in this dissertation has produced in total.
2 THEORETICAL FRAMEWORK

The aim of this second chapter is to present significant recent research in the field of this dissertation. This chapter begins with students’ awareness of science-related careers and working life skills in subchapter 2.1. Next, I describe context-based, more specifically career context, approach in science education, following with the usage of scenarios in science education. Final sub-chapter of theoretical framework presents teachers’ professional development through co-designing and how co-designing instruction is related with teachers’ ownership and agency in developing and implementing educational innovations.

2.1 STUDENTS’ CAREER AWARENESS

In this chapter, students’ career awareness of science-related careers is discussed and what is the role and relation of different competencies such as 21st century skills in students’ perceptions about working life skills.

2.1.1 Science-related careers

People trust in science professionals’ ability to solve problems and recognize the social impact of science careers rather high, for example in Finland (Kiljunen, 2013) and in the U.S. (National Science Board, 2018). However, public might not have accurate perceptions of science careers (Pew Research Center, 2015), for example people strongly associate chemist to pharmacist and with medicine topics but not frequently to industry and technology (Schummer & Spector, 2007). Unfortunately, it seems that also students and teachers need increased awareness of Science, Technology, Engineering and Mathematics (STEM) careers (Knowles, Kelley & Holland, 2018; Reiss & Mujtaba, 2017).

Compared to many other fields, majority of science careers have low visibility in everyday life (Schütte & Köller, 2015). In addition, students indicate not knowing professionals working in STEM fields and education fails to make them aware of these science-related careers (Maltese & Tai, 2011). Hence, several studies confirm that students lack knowledge of STEM careers and the competencies needed in such careers (Archer, DeWitt & Dillon, 2014; Blotnicky, Franz-Odendaal, French & Joy, 2018; Cleaves, 2005). Furthermore, this knowledge is often based on stereotypes that still exists (Miller, Eagly & Linn, 2015; Salonen et al., 2019) because school fails to correct or stop these stereotypes to grow up (Christidou, 2011). However, it is worth noting that a study by Andersen et al. (2014) found out that Danish students with high interest in science ended up having well informed and more realistic perceptions of scientists and the stereotypes they have are positive.

The stereotyped perceptions of science-related careers are found in several previous studies with children’s narratives (Tucker-Raymond et al., 2007); children’s constructions of science (Archer et al., 2010); pictures in books (Rawson & McCool, 2014). These studies reveal children’s perceptions of work in science and science-related careers mainly boring, male-dominated, intellectual and knowledge-oriented.
Studying students’ attitudes towards science careers, Masnick et al. (2010) found that students did not perceive scientific careers particularly creative or including interaction with other people. In addition, these students’ perceptions of careers do not change during adolescence and persist until early adulthood if the students are not provided with accurate information about the careers (Masnick et al., 2010). Ensuring that students get correct information about STEM careers earlier, can rise their possibilities to make informed decisions about STEM studies and careers (Osborne & Collins, 2001; Tai, Liu, Maltese & Fan, 2006). Therefore, Holmegaard, Madsen and Ulriksen (2014) suggests that it is necessary to include career information and education in science curriculum.

In Finland, secondary school students acquire knowledge and information about professions and possible future careers mainly from guidance counsellors, through introduction to work life periods and from home (Taloudellinen tiedotustoimisto, 2016). It is noticeable that teachers and professionals are not in the top of the list. Students’ perceptions about work is based on what they might achieve through the work, for example salaries and publicity, instead of what the actual work might be. Furthermore, students perceive that school lessons are disconnected from the work life and they gain less information than they yearn.

In the previous National Core Curriculum of Finland careers were only part of students counselling (FNBE, 2004). Fortunately, the latest Finnish curriculum reform taken into practice in 2016 emphasize the need for increasing students’ career awareness in every school subject in collaboration with students counselling (FNBE, 2014). Now science education curriculum in Finland has the aim of promoting students’ understanding of the role of science in society, its relevance and importance in their lives and future working life. Therefore, science education should introduce careers in need of scientific knowledge and skills through different contexts (FNBE, 2014). Science education curriculum in Finland shows the importance of scientific knowledge and skills in students’ future careers and working life. All science subjects (physics, chemistry, geography and biology) in the curriculum puts emphasis on three levels of objectives in corresponding science subject: 1) Importance, values and attitudes, 2) Subject and research skills, 3) Knowledge and its use. Teaching delivers an image of science as relevant for sustainable future. Science is needed for future solutions and maintaining wellbeing of humans and environment. Science education guides students to realise the importance of science in their future studies and work life. Students’ are introduced with different contexts and careers including science-related competences (FNBE, 2014).

To fulfil these objectives, educators need instructional innovations using STEM careers and contextualisation, introduced later in subchapter 2.2. Education is not only for increasing knowledge but also developing students’ competencies. Thus, it is worth looking on what competencies curriculum and different stakeholders put weight on because they are an essential part of career awareness.

2.1.2 Working life skills related with 21st century skills

Working life skills are described with many different terms and concepts: job skills, key skills (Jones, 2009), employability skills (Rosenberg, Heimler & Morote, 2012), transferable skills (Pellegrino & Hilton, 2012), generic skills or generic competences (Pešaković, Flogie & Aberšek, 2014). These competences usually gained through
formal education are transferable between careers. However, different environments and fields of work might need and use them differently. These skills are also unknown, misunderstood or controversial among researchers, employers and students (Jang, 2016; Kallioinen, 2010; Lim et al., 2016; Pellegrino & Hilton, 2012). Furthermore, they all indicate different types of working life skills requirements in future.

Several stakeholders participate in preparing and developing the Finnish curriculum reforms. As a result of this collaboration the current curriculum introduces seven broad-based competences: 1) Competence in thinking and learning to learn, 2) Competence in cultural interaction and expression, 3) Looking after oneself and life skills, 4) Multiliteracy, 5) Competence in Information and Communication Technology (ICT), 6) Working life skills and entrepreneurship, 7) Competence in participation, empowerment and responsibility (FNBE, 2014). These competences mix knowledge, skills, values, attitudes.

European employers are looking for adapting workforce with skills like team working, sector-specific skills and communication, computer skills, good reading and writing skills, analytical and problem-solving skills, planning and organisational skills, and decision-making skills (European Commission, 2010). These working life skills could be grouped together with other 21st century skills slightly differently (Binkley et al., 2012; Partnership for 21st Century Learning, 2019; Pellegrino & Hilton, 2012). In their study of different 21st century skill frameworks, Binkley et al. (2012) found four main categories including total of 10 skills categories.

- **Ways of thinking**: Creativity and innovation; critical thinking, problem solving, decision making; and learning to learn, metacognition
- **Ways of working**: Communication, collaboration (teamwork)
- **Tools for working**: Information literacy (includes research on sources, evidence, biases, etc.); ICT literacy
- **Living in the world**: Citizenship - local and global; life and career; personal and social responsibility - including cultural awareness and competence.

There is no doubt that these skills are also important in STEM careers. However, it is not only about the knowledge of skills but also how students relate to these skills, how aware they are about their own skills and their self-efficacy (Cohen & Patterson, 2012). Moreover, students’ stereotypes and self-efficacy beliefs of competencies in science may affect their interest and future career aspirations in science, particularly in Finland (Kang, Keinonen & Salonen, 2019; Lavonen et al., 2008; Uitto, 2014). However, there are differences between science subjects and gender. Students who recognize their current strengths and weaknesses in skills related with STEM careers can also practice these competences through different learning activities in science (King & Glackin, 2010; Wang, 2013). Together with career exploration these science learning experiences can raise students’ career awareness and sense of self-efficacy in science fields. To achieve this, science education needs to encourage students to interpret their learning experiences, which according to Webb-Willimas (2017) is effective in promoting students’ self-efficacy in scientific competences. Students do not see how STEM careers could be personally and socially relevant for them (Jahn & Myers, 2015). Furthermore, they are unable to link their own competencies and interests to their long-term goals. In this DBR, background information was gathered about students’ perceptions about the working life skills to get a grip of how students see science-related careers.
Students generally develop vocational identities during adolescence and use their perceptions to create images of themselves at work in certain careers (Porfeli & Lee, 2012). At this stage, educators need to detect and correct false images and increase students’ awareness of diversity of scientific careers (Archer et al., 2010). Students need to be more aware of their future career plans and what affects these plans. Science teaching must show relations and its usefulness in students’ study and career plans (Andersen & Ward, 2014).

Finally, it is necessary to inform students about scientific careers before stereotypes occur or correct existing ones. Career counselling seems not to be enough, and science education needs to offer lessons promoting understanding of scientific careers and the competencies needed in those careers through everyday contexts (Korpershoek et al., 2012; Potvin & Hasni, 2014). Such contextualisation is included in Finnish science curriculum (FNBE, 2014) and aims to increase students’ interest in science and pursuing science-related careers. In the next chapter I will discuss the basis of the idea of using career contexts in science education.

### 2.2 SCIENCE EDUCATION THROUGH CAREER CONTEXTS

The previous chapters presented the problem of attracting students to choose science and how they lack awareness about scientific occupations and work. However, the concern of recruiting the most competent people in science is not new. Rossi (1965) argued that creative potential of individuals, particularly women, is not fully recognized and harnessed. Those few women who pursued in science had professional and supportive parents or inspirational teachers in science. In the 1970s STEM pipeline was introduced in the USA. This model described linear and narrow steps to become a scientist. The pipeline has since received criticism of its predictive power and ability to promote STEM fields for under-represented student groups (Mendick et al., 2017). Recently, several studies have revealed that science education influences students’ future career choices (Kang & Keinonen, 2018, Lavonen et al., 2008; Potvin & Hasni, 2014).

The reasons for current shortage in science studies and careers are in students’ negative perceptions and attitudes of science and scientific careers (Masnick et al., 2010) and being unaware of career options in STEM (Maltese & Tai, 2011). Moreover, Cleaves (2005) specified that students’ unawareness of science occupations, work and skills, and underestimation of their own science abilities influence future science study and career choices. In addition, Cohen and Patterson (2012) concluded that engagement and relevance were also influencing students’ choices. Conversely, Korpershoek et al. (2012) found out that difficulty of the science studies is not among the factors preventing future science studies and careers. However, high achievers who are not pursuing further science studies or careers tend to lose their interest during school years (Krapp & Prenzel, 2011; Osborne & Dillon, 2008). Students’ interest, attitudes and relevance have been major concerns for researchers and educational systems around the world for a very long time (Osborne, Simon, & Collins, 2003; Stuckey, Mamlok-Naaman, Hofstein & Eilks 2013; Potvin & Hasni, 2014). In fact, instead of looking into the topics and contents of science, it might be more important to look in pedagogical aspects of science education when considering students’ interest and attitudes in science (Krapp & Prenzel, 2011; Potvin & Hasni, 2014).
2.2.1 Students' interest, relevance and career aspirations in science

Students' individual interest (Aspden et al., 2015) and perceived relevance (Stuckey et al., 2013) have major influence on students' science study and career choices. Students' prior knowledge together with their abilities to learn more and encounter new knowledge increases their interest (Tobias, 1994; Schraw & Lehman, 2001). Teaching strategies which engage students in learning processes are seen affecting positively on students' attitudes towards science (Minner, Levy & Century, 2010; Potvin & Hasni, 2014). Students' engagement and further interest are more likely to rise through enjoyment in science learning (Ainley & Ainley, 2011). Enjoyment and other emotional and feeling characterizations in science learning are more likely to increase students' interest and engage them with science also in the future (Ainley & Ainley, 2011).

It seems that, no matter how important science subjects, topics and contents might be for students' future study and career goals, science seems not to be important for students' everyday (Childs, Hayes & O'Dwyer, 2015; Palmer, Burke & Aubusson, 2017). However, students who do not choose science still thinks that it is necessary that others choose scientific careers in the society (Goodrum, Druhan & Abbs, 2012). Thus, the value and relevance of school science can be increased through promoting various aspects of scientific career options (Andersen & Ward, 2014).

STEM orientation and particularly career aspirations has received less attention than individual interest perspectives (Reinhold, Holzberger & Seidel, 2018). At the same time, science teachers have challenges to introduce, promote and use careers in their teaching. In addition, as described in subchapter 2.1 stereotypes of the careers still exists and school science fails to promote the role of women in science. Therefore, Schütte and Köller (2015) claim that school science should concentrate on less visible scientific careers in everyday life instead of traditional ones, for example chemist, physicist and doctor.

Lately, several studies reported teacher-scientist and student-scientist partnerships aiming to promote science careers and increase students' interest and engagement in science learning (Hellgren, 2016; Falloon, 2013; Peker & Dolan, 2012). Personal interaction with science role models in these school-community/industry partnerships increase students' interests in science and scientific careers (cf. Shin et al., 2015). Science role models help to show science as a positive and exciting career option and to correct common stereotypes, particularly with female students (Farland-Smith, 2009). In addition, using STEM careers, authentic tasks; contact with scientists and working collaboratively increases interest, motivation and attitudes towards science (Potvin & Hasni, 2014). In school-community/industry partnerships students are exposed to professionals in their authentic working environments. This promotes students' positive attitudes and increases their career awareness in science (Peker & Dolan, 2012; Houseal, Abd-El-Khalick & Destefano, 2014). Furthermore, both students and teachers acquire the latest scientific knowledge in different fields. School-community/industry partnerships typically involves professional scientists to visit the class or students visiting them in their working environment. There are challenges to form and implement these partnerships. It can be challenging to access the experts, teacher and professional resources, educational restrictions such as curriculum, and lack of existing supportive materials (Evans et al., 2001). These challenges have led to unsuccessful implementations of the partnerships and lately there has been a request for development of new instructions (Falloon, 2013).
Recently science education has shifted towards educating through contexts of science to attract young people to science studies and educate scientifically aware future citizens (European Commission, 2004; 2007; 2009). Research has shown that this kind of context-based approaches improves students’ attitudes and understanding in science (Bennett et al., 2007). This kind of approaches are also included in the science subjects teaching in the Finnish national core curriculum (FNBE, 2014). Science education in Finland aims to promote students’ understanding of its role in society, relevance and importance in their lives and future working life. Therefore, science education should introduce careers in need of scientific knowledge and skills and use different contexts (FNBE, 2014). Moreover, Finnish students who are interested in science and understand its relevance for everyday want more creative ways of learning in science (Juuti et al., 2010). To fulfil these objectives, educators need instruction innovations. Nevertheless, in schools, science is often presented in a decontextualized way, not relating to everyday life, strong academic and abstract character of science is emphasized and links to society often omit (Christidou, 2011; Walper et al., 2014).

To sum, research in science education propose that science education should include much stronger contextualisation to increase students’ interest, attitudes and relevance in science and promote their science career aspirations. One keystone of recent science educational innovations is the context-based learning (CBL) discussed next.

2.2.2 Context-based learning

Even though science topics and contents usually have practical implications in society, industry and work life, teachers struggle to integrate school science in authentic contexts (Kelley & Knowles, 2016). Contextualisation in science education has been used with older students but lately it has been successfully deployed with much younger students as well (King & Henderson, 2018). Research shows that stronger CBL including links outside the school ends with better learning results as well as improved motivation and interest in science. (Bennett et al., 2007). CBL can rely on more traditional science education approaches such as inquiry-based learning and usually the learning experiences in both can include setting a problem, investigations, problem-solving and sharing the results and solutions with others. In addition, CBL introduces all these in a context relevant to students’ lives and interests, future situations they may encounter, technology they are likely interested on and possible future careers (Bennett et al., 2007).

Previous research shows various positive effects of CBL in science education. Students interest remains stable or increases when they are able to connect school science and everyday life practical situations (Krapp & Prenzel, 2011). In addition, real-world contextual issues and discussions increase relevance of school science (Broman, Bernholt & Parchman, 2018; Cigdemogly & Geban, 2015; Stuckey et al., 2013). However, if the contextual framing is unknown and from too far, globally or socially, of the students’ everyday it might decrease their interest in science (Ainley & Ainley, 2011). Thus, the future research on CBL should include how students learn in different CBL settings, how these settings accrue various social, culture and cognitive outcomes, and teachers’ learning and professionalisation (Sevian, Dori & Parchman, 2018). Nevertheless, different kind of context-based approaches, for example Science-Technology-Society (STS; Aikenhead, 1992; 1994) and previously mentioned SSI (Sadler, 2011) improve students’ interest, motivation and attitudes towards science
SSIs are open-ended complex societal issues or problems with links to science content or concepts (Sadler, 2011). Moreover, these challenges create suitable contexts for science education to show students how school science is related with their lives. These issues provide a solid ground for the proposed instruction in this dissertation to introduce students to science-related careers that address to these problems with their various skills and competences in their work. CBL, STS and SSI address also to other than knowledge and attitudinal goals in science education, for example required skills and participation in society (Holbrook & Rannikmäe, 2007; Ekborg, Ottander, Silfver & Simon, 2012).

Students may have specific interests (e.g. automation and robots, climate and pollution) subject-level preferences (e.g. engineering, technology, natural sciences) and some of these topics and domains might be more popular than others (Bathgate, Schunn & Correnti, 2014; ByBee & McCrae, 2011). However, contexts as starting point in science teaching are still particularly good in improving students’ attitudes (Bennett et al., 2007; King & Henderson, 2018). In addition, a positive sign of scientific career interest has recently been found from the field of chemistry education. Habig et al. (2018) found that career contexts increase students’ overall interest in chemistry and vice versa.

2.2.3 Career-based scenarios in science teaching

One contextualised instruction innovation as starting point for science teaching is using scenarios. Scenarios in science education act as starting point for further learning and include links with science content and everyday life (Bennett et al., 2007; Bolte et al., 2012). Moreover, the scenarios involve and engage students in motivational scientific thinking and science learning (Holbrook & Rannikmäe, 2010). The scenario also initiates the learning process, by not only pointing out scientific knowledge, but also highlighting working life skills and guiding participation for activities such as inquiries, expressing opinions, and socio-scientific decision making (Holbrook & Rannikmäe, 2010). Successful implementations of scenarios in science education has been reported particularly in the EU funded teacher professional development project PROFILES (Bolte & Rauch, 2014).

In the MultiCO project and this dissertation, the students are taught science in an innovative and relevant way using scenarios with career contexts linked with scientific and technological developments with society (Holbrook & Rannikmäe, 2010). These career-based scenarios present scientific careers and scientists through different ways, for example with career stories, videos, interviews and visits. According to the studies presented in previous chapters, these learning experiences increase students perceived interest, attitudes and relevance in science. In addition, students are involved in scientific processes that are authentic (Brossard, Lewenstein & Bonney, 2005). Career-based scenarios are suitable to be used along with different types of science topics and contents, for example life cycle of consumer products (Tolppanen et al, 2019) and acoustics (Drymiotou, Papadouris & Constantinou, 2018). These studies report positive students’ personal and social relevance and interest in science learning but two-folded career relevance as students gain knowledge of careers but their career aspirations in single scenario interventions remains almost unchanged.

In sum, ways to improve students’ interest and relevance in STEM studies and careers can include CBL in and out of class with problem-based learning, inquiries,
links between science and reality, field trips and visits, contact with professionals, giving equal opportunities to both genders and using adequate amount of Information and Communication Technology (ICT). Designing, creating and implementing such interventions takes time. Evaluating and reflecting these interventions within the framework of DBR leads to new instruction innovations in science education.

2.3 CO-DESIGNING SCIENCE EDUCATION

As described in the previous chapters, there are numerous variables in students’ career awareness and their aspirations in science. Educational research has already found some possible pedagogical guidelines how to overcome the challenge of students’ not pursuing science studies and careers. Therefore, to keep up, all teachers need to improve their teaching methods, for example by adopting, altering and developing novel instructional designs (Avalos, 2010). As well as the major global challenges related with science, also challenges in science education require broad-based competencies. Facing these challenges alone can be overwhelming for educators. Thus, co-designing offers a realistic possibility to address these challenges and take the actual school requirements and resources into account (Juuti, Lavonen & Meisalo, 2016). This chapter introduces how teachers can develop their professionality through co-designing and how teachers’ ownership and agency relate with co-designing in educational development work.

2.3.1 Teacher professional development through collaboration

Clarke and Hollingsworth (2002) suggest in their interconnected model that the teacher professional growth occurs through personal (knowledge, beliefs and attitudes), practice (professional experimentation), consequence (salient outcomes) and external (information, stimulus or support sources) domains. The first three link to the teacher’s professional and practical world including their actions and consequences. The external domain is not part of the teacher’s personal world but can still make a change in other domains. Their model recognize that reflection and enactment are processes that by a change in one domain may lead to changes in another domain (Clarke & Hollingsworth, 2002). Teaching and learning are increasingly structured as community-based collaboration between teachers and other school community members (Darling-Hammond, Hyler & Gardner, 2017). Therefore, it is important that teacher professional development includes features of teacher collaboration (Mamlook-Naaman, Eilks, Bodner & Hofstein, 2018).

Teachers’ existing personal domain is not acknowledged when imposing them new educational innovations developed by someone else (van Driel, Beijaard & Verloop, 2001). Therefore, such top-down attempts usually fail or are not effective (Blonder et al., 2008). Converse approach, namely bottom-up, increases teachers’ perception of owning the innovation; they feel it belongs to them (Ogborn, 2002). However, by using the best out of both approaches it is possible to fast and easily introduce in-service teachers with new ideas, instructions and educational philosophies but also making explicit their personal domain. This approach is sometimes referred to as middle-out approach (Cummin, Phillips, Tilbrook & Lowe, 2005). Researchers, professionals or other experts included in these scaffolding processes support educators implementing
new instructions (Darling-Hammond et al., 2017). As mentioned in subchapter 2.2, school-community/industry partnerships are important for students’ career awareness and science learning, but also for bringing teachers and scientists together as educational partners (Snitynsky, Rose & Pegg, J. 2019). This type of collaboration through partnerships helps educators to understand the relevance and usefulness of educational planning (Voogt et al., 2015).

One way of collaboration between teacher peers, students, researchers, professionals and other stakeholders is co-designing. Educational co-designing is creating or adapting teaching methods and learning activities through multi-professional groups with up-to-date insights and new ideas (Könings, Seidel & Merrienboer, 2014). Teachers can understand the models and gain new competences in planning and implementing different instructions (Voogt et al., 2015). Furthermore, co-designing curricular and instructional models help teachers to realize their practical visions on which they can base their learning and professional growth (Darling-Hammond et al., 2017). Though not forgetting their personal domain and expertise. Thus, during the interaction of co-designing, teachers can reflect their personal domain in relation to the designed material (cf. Ketelaar, Beijaard, Den Brok & Boshuizen, 2013). Whenever teachers design and implement novel educational innovations their sense of ownership and agency plays a remarkable role in making it work (Ketelaar et al., 2013). Therefore, study III investigates teachers’ ownership and agency to understand their perceptions of co-designing educational innovation and how to continue developing the instruction further.

2.3.2 Teachers’ ownership and agency in educational co-designing

Ownership and agency are closely related with identity. When one is welcoming, accepting and possessing ideas, concepts or in this study educational innovation, as part of their identity, they feel ownership towards these ideas and concepts. Thus, ownership is not only a mental state or feeling of owning the educational innovation and what is important in it for the owner (Pierce, Kostova, & Dirks, 2001). It is a matter of their mental or physical effort for the innovation to succeed (Struckman & Yammarino, 2003). However, only if the owner feels that a change is necessary in current situation, they are willing to provide their effort in designing, implementing and reflecting the innovation (Ketelaar, 2012). For ownership to develop teachers as implementors of educational innovations must identify themselves with the innovation (Pierce et al., 2003) and support the design and ideas (Breiting, 2008). Ownership exists when teachers are given possibilities, support and recognition of their efforts in co-constructing new knowledge and educational improvements (Saunders et al., 2017).

Teacher agency is defined as their capacity of acting with problems and challenges to solve them. According to Biesta, Priestley and Robinson (2015), it is not something teachers have but what they do and achieve through their capabilities and environmental conditions. Furthermore, they have identified three dimensions of agency: past experiences, future orientations and engagement here and now. Teachers who feel they are in control of their actions experience agency (Metcalfe & Greene, 2007). Moreover, their goals, interests and motivation are guiding their work-related choices (Vähäsantanen et al., 2008). However, particularly in countries with high teacher autonomy, such as Finland, teachers might feel that novel educational innovations reduce their feel of control (Konopasky & Sheridan, 2016) and limit their
autonomy to define their teaching (Allen & Penuel, 2015). Teachers need high level of autonomy and possibilities to have open discussions within the work environment to make these work-related choices. Teachers’ sense of agency increases when their beliefs and attitudes align with new educational innovations. Then, it is easier for them to accommodate with the innovation (Ketelaar, Beijaard, Boshuizen & Den Brok, 2012). Instead of concentrating on external and negative factors of the innovation, teachers who link successes and failures to themselves show a strong sense of agency in the process (Marshall & Drummond, 2006).

As this chapter has already shown, teacher’s ownership and agency are extensively studied. To sum, the literature review in study III revealed categories displayed in Table 1 affecting teachers’ ownership and agency in educational instruction design, implementation and reflection processes.

Table 1. The deductive approach to form categories of ownership and agency in study III.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership</td>
<td></td>
</tr>
<tr>
<td>Supporting the design or ideas</td>
<td>Breiting (2008)</td>
</tr>
<tr>
<td>Mental/physical effort</td>
<td>Struckman &amp; Yammarino (2003)</td>
</tr>
<tr>
<td>Identifying with the instruction</td>
<td>Pierce et al. (2001)</td>
</tr>
<tr>
<td>Need for change</td>
<td>Ketelaar (2012)</td>
</tr>
<tr>
<td>Agency</td>
<td></td>
</tr>
<tr>
<td>Accommodation</td>
<td>Ketelaar et al. (2012)</td>
</tr>
<tr>
<td>Autonomy</td>
<td>Allen &amp; Penuel (2015)</td>
</tr>
<tr>
<td>Feel of control</td>
<td>Konopasky &amp; Sheridan (2016); Metcalfe &amp; Greene (2007)</td>
</tr>
</tbody>
</table>

Teachers are interested about the salient outcomes of teaching they implement (Clarke & Hollingsworth, 2002) and this enables teachers to associate with gains in students’ learning outcomes and make changes in their practice (Darling-Hammond et al., 2017). This sets the latest educational knowledge and methods under their scope for finding how to enable students’ engagement in science learning and future careers. Promoting teachers’ agency throughout implementing educational innovations within in their work affects their response of the innovation (Ketelaar, 2012). Therefore, also in this dissertation it is important to find out teachers’ experiences of ownership and agency to identify their own work-related goals and understanding and compare those with the choices they make. In addition, co-designing not only between teachers, but also between teachers, professionals, researchers and students are important in developing instruction model through DBR. Working through research and societal framework stages, practical stages and finally bottom-up stages, teachers and other stakeholders learn from each other and achieve professional development (Aksela, 2019). In addition, co-designing bridges the latest research, educational innovations, practice and curriculum requirements in science education.
2.4 SUMMARY OF THE THEORETICAL FRAMEWORK

The previous chapters introduced the theoretical framework tackling the challenge of students’ low aspirations in science studies and careers. Figure 1 presents a summary of the framework and the relations between the key concepts.

Figure 1. Summary of the theoretical framework, key concepts and their relations in this dissertation.

Previous research has revealed that students’ aspirations in science studies and careers can be promoted by increasing their awareness of the career possibilities and making the science interesting and relevant for students. Instructional innovations in science education included also in science curriculum, such as CBL, SSI and using scenarios all enhance the relevance of science. Moreover, when choosing contexts, issues and scenarios from society, industry and work life these approaches can provide accurate information about careers and the required skills for students. However, these strong factors and predictors of students’ science aspirations have not been successfully connected in the past. Therefore, this dissertation considers both students’ and teachers’ perceptions about co-designed science education with the aim of promoting students’ career awareness and science attractiveness.
3 AIMS OF THE RESEARCH

As mentioned in Chapter 2, the overall aim of the dissertation is to find out how career-related instruction including career-based scenarios effects in students’ scientific career awareness and science attractiveness. The focus is on a design process of career-based scenarios linking school science, industry, society and scientific careers. In addition, this dissertation clarifies how using career-based scenarios in science education stimulate students and relate with educational gains of increasing students’ awareness of careers and working life skills. Furthermore, instructional framework is developed through DBR. Contexts can strongly increase science and science careers’ attractiveness. In addition, careers as a context increase students’ career awareness and perceived relevance of individual, social and vocational dimensions. Therefore, career-related instruction including career-based scenarios is identified as a possible solution to the students’ lack of science career awareness and interest in pursuing science studies and careers. Moreover, research has indicated that science teachers are keen to explore new ways of teaching and using different contexts in science but struggle to include careers as one. This might be due to obstacles with resources such as time and contacts with career professionals, but there is also lack of theoretical and practical evidence and implications supporting the idea. Therefore, this article-based dissertation seeks to examine and answer the following research questions and objectives.

1. What are the students’ perceptions of working life skills in science-related careers and how they differ when considering various science-related careers? (Study I)
2. How career-related instruction effects on students’ career awareness and perceived interest and relevance towards science topics and science learning? (Studies II and III)
3. What are the teachers and students’ perceptions about career-based scenarios and career-related instruction in science education? (Studies II and III)
4. How the teachers worked through design, implementation and evaluation steps of developing career-based scenarios and the related instructions? (Studies II and III)

As presented in Figure 2, the present dissertation is based on three original studies and complemented with results reported in the MultiCO project deliverables. Previous research revealed that students are unaware of science-related careers and stereotypes about the careers exists. However, converse results also exist, particularly with students who are interested in science. Therefore, study I examines how aware the Finnish students are about the competences required in science-related careers.
Figure 2. Overall aim of the dissertation and sub-study research questions.

These results were then used in designing educational interventions increasing students’ awareness of the careers and the working life skills. First and pilot intervention was implemented in Spring 2016 and presented in the MultiCO project deliverable and briefly in this dissertation. Study II reports the second intervention in Fall 2016 in detail with the support of observational data. Aim of the study II is to provide deeper understanding about career-based scenarios in science education. What happens during the instruction and what are the students’ perceptions about a career-based scenario as part of the career-related instruction? Furthermore, study III, with the results from third intervention in Spring 2017, develops a view of teachers’ ownership and agency when participating in co-design process of career-related instruction. Fourth intervention was carried out in Fall 2017 and is also reported in the MultiCO project deliverables and briefly in research contribution of this dissertation in Chapter 5. Studies II and III and the results from the MultiCO project deliverables provide also practical insights for educators how to provide students with information about the science-related careers and working life skills. The results provide deeper understanding of how aware the students are of the science-related careers and how instructional designs can be used in science education to promote science careers and studies. Detailed information about the DBR as a research method in the dissertation is described in Chapter 4.
4 METHODS

According to Wertsch, del Rio and Alvarez (1995) sociocultural research should not only investigate human action but also change the action in different settings. Educational research aims to understand teaching and learning but it also has pragmatic objectives to improve teaching and learning (Juuti & Lavonen, 2006). The purpose of this dissertation is both to gain understanding and practical implications of career-related instruction through perceptions of different stakeholders: teachers, professionals and students. Pragmatism as the philosophical background and mixed methods throughout the DBR in this study acknowledge the nature of knowledge and learning and focus on what is relevant and effective in science education.

4.1 PRAGMATISM AS PHILOSOPHICAL BACKGROUND

Pragmatism as a philosophical tradition acknowledge that knowing is inseparably connected with agency in the world (Legg & Hookway, 2019). This general assumption has attracted many philosophers such as Charles Sanders Peirce (1839-1914), William James (1842-1910) and John Dewey (1859-1952) to create various interpretations of the idea. Their development and popularisation of pragmatism is widely accepted and has led to a conclusion that all philosophical concepts should be tested through scientific experiments, and only if the claims are useful, they are considered as true. There are of course different variations within pragmatism, but Peirce, James and Dewey all agreed that examining empirical findings helps to decide the next steps in understanding real-world concepts and phenomena (Johnson & Onwuegbuzie, 2004). In addition, all the different orientations of pragmatism highlight agency and practice in research, problem-solving and creating new knowledge. According to Dewey, research always tries to solve a problem raised from practical experiences. Therefore, in the light of pragmatism, research is not limited to scientific research but also to everyday life. This naturalistic view of research also does not make clear boundaries between the knowledge (“know that”) and skills (“know how”). This vision also posits that all learning and teaching happens through practical abilities and competencies shaped by the contexts and results to a “problem-centred pedagogy” (Legg & Hookway, 2019).

According to Paavola and Hakkarainen (2008), reasoning is a socially and physically oriented process instead of individual and mental process. This point of view underlines the interaction of people and cultures in pragmatism and problem-solving. In addition, it requires collaboration and environmental resources. This leads to a conclusion that creating new knowledge and using it in different contexts is possible through interaction between people, cultures, environment and physical resources and tools (Paavola & Hakkarainen, 2008; Morgan, 2007).

In traditional theory-testing paradigms, design and research are sequential phases of research process (Edelson, 2002), but design can have a significant role in theory development as well, particularly in DBR, which goes beyond explaining interventions of learning (Barab & Kirschner, 2001). Pragmatism as a philosophical background for DBR in education acknowledge the lack of knowledge how to act in different educational settings, but DBR can construct practical implications and
understanding of these teaching and learning situations (Juuti, Lavonen & Meisalo, 2016). For this, pragmatism offers researchers the possibility of philosophically and methodologically using various practical and outcome-oriented inquiries in action (Johnson & Onwuegbuzie, 2004). Various mixtures of methodological choices help conducting research that have many different possibilities and routes to address the research questions. Thus, pragmatism enables the use of multiple approaches and mixed methods research.

4.2 MIXED METHODS

Mixed methods in educational research is practical and researcher can use various methods addressing the research problem (Creswell, 2014). This methodological approach makes it possible to gather numerical and verbal data as well as inductive and deductive ways of analysing that data (Creswell & Plano Clark, 2011). In mixed methods research qualitative and quantitative research elements are connected to create wider and deeper understanding of the phenomena under research, which neither research elements could do independently (Creswell, 2014; Johnson & Christensen, 2014). Moreover, mixed methods is a suitable methodology approach when one data source is insufficient to explain the phenomena, and additional methods promotes the use of another one. Research might benefit from qualitatively describing the phenomena, but it is also necessary to generalize the results to some extent (Creswell & Plano Clark, 2011). In addition, qualitative data reveals the participants' perceptions better, which address to this weakness of quantitative research. Different data can be gathered simultaneously or separately. Moreover, different datasets can be equal or non-equal (Johnson et al., 2007). One dataset can be primary but not necessarily. The research can also compare different types of gathered data to gain additional perspectives or validate the other.

The data integration is typical to mixed methods and can be done in multiple phases of research (Johnson & Onwuegbuzie, 2004). In the three single studies, the integration was done during reporting the analysis and results. In overall, the DBR presented in this dissertation integrates the previous qualitative and quantitative data also in the developmental work between the interventions. Thus, the results are utilized immediately and mixing the methods and results over single studies provides even more explanatory and generalized results and implications.

4.3 DESIGN-BASED RESEARCH

The design-based research (DBR) originates from the real-world context learning process and intervention experiments of Collins (1992) and Brown (1992). Since then interest has increased in DBR among educational researchers (Anderson & Shattuck, 2012). Pragmatic frame for DBR makes it possible to recognize a change, create usable solutions and knowledge for more advanced praxis (Juuti, Lavonen & Meisalo, 2016). Therefore, DBR can be used to study learning through different environments, which are designed and systematically changed, managed, designed and refined in collaboration with the participants (Barab, 2006; Wang & Hannafin, 2005). DBR involves practitioners as valuable partners (Amiel & Reeves, 2008) to develop possible solutions to identified problems with educational context. These different kinds of
designed solutions such as educational methods, processes and policies are defined as interventions (McKenney & Reeves, 2019). Interventions are testing new instructional approaches and learning activities (Anderson & Shattuck, 2012). This study identifies career-related instruction with career-based scenarios as a possible solution to the students’ lack of science career awareness and interest in pursuing science studies and careers. We study the design problem with the perspectives of the people who implemented and carried the interventions through (Herrington & Reeves, 2011). This collaboration in interventions enhance the practicality and relevance of the designed solutions for the use of science education (Plomp, 2009).

DBR can last for many years and contain several steps before, during and after the interventions. In their generic model of education design research, McKenney and Reeves (2019) names three main phases: analysis and exploration, design and construction, and evaluation and reflection (Figure 3). Analysis and exploration include literature review and input of stakeholders such as experts, industry partners, educators and other participants, in this case students. The aim is to identify the content, structure and instruction approaches of the interventions and first draft design principles. The research group uses these elements to design the first intervention. Design and construction phase can include multiple interventions and refining the design problems, principles and solutions between those interventions.

Figure 3. The generic model of the DBR conducted in this dissertation (cf. McKenney & Reeves, 2019)

These intervention designs and principles are then evaluated and reflected to either go back to earlier phases or further delivering theoretical understanding and mature interventions (McKenney & Reeves, 2019). Hence, the process is typically cyclical and involving different activities several times until founding a balance between idealistic intentions and realistic practice (Plomp, 2009).

During the process, the three main phases constantly interact with the education practice, implementation and dissemination of the design. It is important to notice that educational interventions can be useful and advanced without fully understanding how it works (Bielaczyc, 2013). In addition, local context is not only affecting the research but the changes in local context arising from the design experiment are evidence of theory’s viability (Barab & Squire, 2004). Even though presenting local and practical gains is important part of DBR, the long-term focus is on developing a
design and new theories (Barab, 2006), refining and producing design elements (Amiel & Reeves, 2008). Thus, the research process involves continuous data collection to provide enough data for the research cycles: analysis, design, evaluation and revision. Even though the outcome of DBR is often developing a theory, it might be that this needs long-term research and engagement beyond the researchers’ available time and resources (Anderson and Shattuck, 2012). Therefore, DBR provides design principles and guidelines, not only to evaluate the designed interventions but for attempts to systematically refine the novel product and provide information for further research and development (Amiel & Reeves, 2008).

4.4 PARTICIPANTS

The present dissertation and all the studies included collaboration over researchers, teachers, students and other stakeholders such as industry and science professionals involved in European project, MultiCO (“Promoting Youth Scientific Career Awareness and its Attractiveness through Multi-stakeholder Cooperation”). Science teachers around Eastern Finland were contacted and voluntaries with future 7th grade classes were invited to participate in the project. In the study I, 144 Finnish 7th graders (aged 13–14 years) from three different lower secondary schools in Eastern Finland worked in small groups of two to three persons and discussed about science-related careers and the competences needed in these careers. In studies II and III, two teachers from one of the schools in study I designed, created and implemented, in collaboration with researchers and other stakeholders, career-based instructions starting with career-based scenarios in science education interventions. Furthermore, their 46 students evaluated these scenarios and educational instructions over two and half years between 2016 and 2018.

4.5 DATA COLLECTION AND ANALYSIS

In general, data were collected from multiple sources (Table 2). Different approaches and mixed methods were used to ensure the understanding of complex educational situations and the use of designed instructions. All the data was collected by the main author and provided by the participant teachers, students and other stakeholders. The data consists of notes and audio-records from planning and implementing the four interventions, retrospective interviews of the teachers, and the students’ instruction evaluation questionnaires (scenario and intervention) and lesson observations. All this data forms the continuum of the development of career-based scenarios and career-related instruction.
Table 2. Data collection and analysis.

<table>
<thead>
<tr>
<th></th>
<th>Participants</th>
<th>Data collection</th>
<th>Data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-phase</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study I</td>
<td>Students (n=144)</td>
<td>Questionnaire: Working life skills in science-related careers</td>
<td>Inductive and deductive content analysis with quantification</td>
</tr>
<tr>
<td><strong>Before</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>interventions</strong></td>
<td>Study II</td>
<td>Teachers (n=2) Notes and audio records of planning meetings</td>
<td>Inductive content analysis</td>
</tr>
<tr>
<td></td>
<td>Study III</td>
<td>Teachers (n=2) Notes and audio records of planning meetings</td>
<td>Inductive content analysis</td>
</tr>
<tr>
<td><strong>During</strong></td>
<td>Study II</td>
<td>Teachers (n=2) Notes of discussions between teachers and researchers</td>
<td>Inductive content analysis</td>
</tr>
<tr>
<td><strong>interventions</strong></td>
<td>Study III</td>
<td>Students (n=39) Observations: video-records and notes</td>
<td>Inductive content analysis</td>
</tr>
<tr>
<td></td>
<td>Study III</td>
<td>Teachers (n=2) Notes of discussions between teachers and researchers</td>
<td>Inductive and deductive content analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Students (n=41) Scenario evaluation questionnaire</td>
<td>Quantitative descriptive analysis</td>
</tr>
<tr>
<td><strong>After</strong></td>
<td>Study II</td>
<td>Teachers (n=2) Notes of discussions between teachers and researchers</td>
<td>Inductive content analysis</td>
</tr>
<tr>
<td><strong>interventions</strong></td>
<td>Study III</td>
<td>Students (n=39) Intervention evaluation questionnaire</td>
<td>Quantitative descriptive analysis</td>
</tr>
<tr>
<td></td>
<td>Study III</td>
<td>Teachers (n=2) Notes of discussions between teachers and researchers</td>
<td>Inductive content analysis</td>
</tr>
<tr>
<td><strong>Post-phase</strong></td>
<td>Study III</td>
<td>Teachers (n=2) Retrospective interviews</td>
<td>Inductive and deductive content analysis</td>
</tr>
</tbody>
</table>

The data was collected in the pre-phase, before, during and after each intervention, and in the post-phase. In addition, before the first intervention, teachers participated in a collaborative planning meeting with researchers and all the participating teachers in MultiCO project. In this meeting, the idea of career-based scenario was introduced to the teachers and they had an opportunity to share their perceptions about careers as a context in science education.

Before, during and after the interventions the data from teachers were collected with informal interviews, which included questions in a natural interaction, typically during ongoing observations. This type of informal conversational interviews does not rely on specific pre-made questions, but rather on momentary and genuine interaction between the researcher and participant (Turner, 2010). Teacher retrospective interviews in this study were semi-structured interviews with research themes and open-ended questions (DiCicco-Bloom & Crabtree, 2006). Students' perceptions about the scenarios and interventions were examined with a questionnaire including relevance (individual, societal and vocational) and interest (general, value, affect and knowledge) variables (Kang et al., 2019; Kotkas, Holbrook & Rannikmäe 2017; Stuckey et al, 2013). In addition to questionnaire data, observations and video-recording were used to better capture student action and immediate reactions to the ongoing teaching and learning situations. All teacher and student data collected and analysed with mixed methods complemented each other to guide the design process of next intervention.
and the whole DBR process. For example, pre-phase questionnaire about the working life skills in science-related careers gave important practical results of how to choose, approach and introduce different competencies of science-related careers.

Notes and interview data were transcript and analysed with content analysis immediately after each intervention and simultaneously with other data, for example intervention evaluation questionnaire, to improve the following design and construction phases (Wang & Hannafin, 2005). The descriptive statistics of instruction evaluation questionnaires are presented in Chapter 5. Retrospectively done analysis address to goals related with generating theory and instruction model of career-related instruction.

Most of the data was analysed using qualitative content analysis (Elo & Kyngäs, 2008) with inductive and/or deductive approaches (Table 2, Figure 4).

![Diagram](image_url)

**Figure 4.** Content analysis in study I.
Content analysis is particularly useful when the focus is on what the data tells us about the studied phenomenon (Schreier, 2012; Tuomi & Sarajärvi, 2009). Content analysis begins with preparation phase which starts by transcribing the data. Next, transcripts are read to make sense of the whole data and then coding the analysis units. Analysis units can be words, sentences or a larger content (Schreier, 2012). Content analysis continues by reading the data and codes to make decisions on how to proceed in the analysis. Typically choosing inductive or deductive approach is done latest at the beginning of organising phase. In this dissertation inductive (study II), deductive (study III) and a mixed approach (study I, Figure 4) are used. In inductive approach the data is handled as it is, and categories are formed freely based on the data. Sometimes deductive approach can be used to explain or conceptualize the results of inductive approach. In contrast, in deductive approach of content analysis categories are constructed through literature review. Deductive approach of content analysis was used in study III which examined teachers’ ownership and agency during the co-design process of one of the instructions. In this analysis previous literature of the key concepts was used to create categorization for further content analysis. Depending on the data and analysis in the three original studies, codes and category names and content varied when necessary.

Quantitative descriptive analysis with means and standard deviations of validated (Kang et al., 2018; Kotkas et al. 2017) students’ questionnaire answers are complemented with their open-ended question answers.

4.6 QUALITY AND ETHICS OF RESEARCH

This dissertation relies on both quantitative and qualitative research, though with emphasis on qualitative research. Therefore, credibility, dependability, confirmability and transferability are key quality criteria for the chosen research strategy. Credibility of the research is increased through prolonged engagement and longitudinal research design but also with method and data triangulation. Each data collection method has advantages and disadvantages. A mixture of methods and instruments is a way to better triangulate of the data collection and analysis (Fredricks & McColskey, 2012; Greene, 2015). For example, interviews are usually retrospective in nature. The participants reflect to what they remember about past experiences and what they think about them now. Therefore, observations, discussions and notes were also conducted during this research. Furthermore, methods can vary in DBR process when the need for new instruments emerge (Wang & Hannafin, 2005). Continuous analysis and getting back to previous results of analysis is in a key role of conducting DBR, it also improves the dependability of the research through iterative processes. DBR grounds in relevant research but will refine both theory and practice to yield research results adaptable elsewhere and valid in subsequent use (Barab & Squire, 2004). The adaptability of DBR raises a question of confirmability of the research. This is addressed by discussing data collection, analysis and results with national and international research team members and comparing results from additional schools in Finland and other countries using similar educational approach. Two researchers analysing the data in content analysis separately and ending up with similar categories enhance the analyst triangulation and the overall reliability of the conducted research (Martella, Nelson, Morgan & Marchand-Martella, 2014). Transferability of the research is improved with bridging different viewpoints of existing literature and discussing emerging results with them.
In addition, reliability and validity are increased through detailed descriptions of interventions, data collection and analysis. All the quantitative research instruments are validated (Kang et al., 2019; Kotkas et al., 2017).

Even though research in education acknowledge the benefits of DBR, it has received some critique. For example, can DBR produce reliable statements about the design if the researchers are involved in developing and implementing the interventions (Barab & Squire, 2004). Another difficulty is the strong contextual approach; it is almost impossible to replicate the interventions (Fishman et al., 2004), in this case, because of limited time and strict curriculum objectives.

Whenever DBR is conducted in education settings, ethical considerations are necessary. Before the MultiCO project was launched the university’s committee on research ethics was consulted and they agreed there was no need for further ethical review in the research as MultiCO-project is carrying out. In addition, the research has followed the ethical regulations and instructions in EU, national and institutional levels. EU has received ethical statements before and during the project progress. Thus, the project and experiments were performed in compliance with the university’s policy on ethics, national and international laws, and guidelines such as the Personal Data Act. Even though the studies were carried out as part of the project, the participation was always voluntary, and all the collected data was anonymous or pseudonymised. The consent for students’ participation was also asked from their guardians and the school administration.
5 RESEARCH CONTRIBUTION

This chapter provides a step-by-step description of acquiring background for the design solutions and further designing, implementing and evaluating the interventions in practice. This chapter focuses on summarising and reviewing the original studies I-III. In addition, corresponding contributions of first and fourth interventions reported in MultiCO project deliverables are included to avoid gaps in the DBR process.

5.1 BACKGROUND: STUDENTS’ PERCEPTIONS OF WORKING LIFE SKILLS (STUDY I)


The objectives of this study are to find out what skills students link with science-related careers and how these perceptions differ between various science-related careers. Thus, this study gives insights of the students’ career awareness and how it could be promoted more efficiently in science education. Students’ are presented with various science-related career pairs and asked to list all the skills needed in these careers in a questionnaire. Career pairs are chosen from a list consisting ‘careers in science’ and ‘careers with science’, one from each. ‘Careers in science’ include careers involved working in scientific fields and ‘careers with science’ use scientific competences as tools or sources.

Results show that the secondary school students possess extensive variety of knowledge about working life skills. Table 3 presents the results of content analysis and quantification of the skills. Students highlight Tools for working, for example sector-specific knowledge and skills. Conversely, the skills that are in the literature but are missing in students’ perceptions are related with society or citizenship, organisational skills and time management skills. The answers also lack the higher order thinking skills. Students also have a sense of what kind of Ways of Working and Ways of Thinking are included in working life skills. Typically, students describe what kind of person or what kind of physical attributes or qualities are needed in a particular career. Moreover, these attributes distribute equally on every career. Similarly, collaborative skills were considered as being needed in most of the careers. Instead of pointing out higher order thinking skills students emphasize a specific mindset, for example precision, as more relevant in science-related careers. Students link responsibilities and confidence with science-related careers but those are the only Living in the world skills they mention.
Table 3. Categorisation of working life skills the students mentioned.

<table>
<thead>
<tr>
<th>Tools for working</th>
<th>Ways of working</th>
<th>Ways of thinking</th>
<th>Living in the world</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sector-specific knowledge</strong></td>
<td><strong>Personal attributes</strong></td>
<td><strong>Communication</strong></td>
<td><strong>Collaboration and teamwork</strong></td>
</tr>
<tr>
<td>Biology (56)</td>
<td>Mental attributes (41)</td>
<td>Language skills (20)</td>
<td>Getting along with people (17)</td>
</tr>
<tr>
<td>Medicine (39)</td>
<td>Self-control (26)</td>
<td>Oral skills (11)</td>
<td>Social skills (17)</td>
</tr>
<tr>
<td>Other knowledge (34)</td>
<td>Physical attributes (9)</td>
<td>Writing skills (8)</td>
<td>Leadership skills (8)</td>
</tr>
<tr>
<td>Geography (23)</td>
<td></td>
<td>Presentation skills (3)</td>
<td></td>
</tr>
<tr>
<td>Chemistry (21)</td>
<td></td>
<td>Communication skills (2)</td>
<td></td>
</tr>
<tr>
<td>Mathematics (18)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physics (18)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sector-specific skills</strong></td>
<td></td>
<td>Language skills (20)</td>
<td>Getting along with people (17)</td>
</tr>
<tr>
<td>Scientific and research skills (31)</td>
<td>Oral skills (11)</td>
<td>Oral skills (11)</td>
<td>Social skills (17)</td>
</tr>
<tr>
<td>Manual and technical skills (23)</td>
<td>Writing skills (8)</td>
<td>Writing skills (8)</td>
<td>Leadership skills (8)</td>
</tr>
<tr>
<td>Practical skills (13)</td>
<td>Presentation skills (3)</td>
<td>Presentation skills (3)</td>
<td></td>
</tr>
<tr>
<td>Design and planning skills (5)</td>
<td>Communication skills (2)</td>
<td>Communication skills (2)</td>
<td></td>
</tr>
<tr>
<td>Logical skills (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technology and ICT literacy</strong></td>
<td></td>
<td>ICT skills (18)</td>
<td></td>
</tr>
<tr>
<td>ICT skills (18)</td>
<td>Technology (11)</td>
<td>Technology (11)</td>
<td></td>
</tr>
<tr>
<td>Follow technological progress (1)</td>
<td></td>
<td>Follow technological progress (1)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Ways of thinking</strong></th>
<th><strong>Creativity and innovation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mindset</td>
<td>Finding solutions (9)</td>
</tr>
<tr>
<td>Precision (22)</td>
<td>Finding problem (6)</td>
</tr>
<tr>
<td>Intelligence (15)</td>
<td>Analysing problem (5)</td>
</tr>
<tr>
<td>Attitudes (7)</td>
<td>Identifying problem (5)</td>
</tr>
<tr>
<td>Interests (5)</td>
<td>Implementation (4)</td>
</tr>
<tr>
<td>Flexibility (3)</td>
<td>Problem solving (1)</td>
</tr>
<tr>
<td></td>
<td>Understanding (1)</td>
</tr>
<tr>
<td></td>
<td>Creativity and innovation (15)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Living in the world</th>
<th><strong>Personal and social responsibility</strong></th>
<th><strong>Citizenship – local and global</strong></th>
<th><strong>Life and career</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsibility and confidence (9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taking care (5)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5 presents the variation in the data between ‘careers in science’ and ‘careers with science’. The ratio of sector-specific knowledge and skills is obvious between ‘careers in science’ and ‘career with science’. The first being more knowledge than skills oriented. Also compared to ‘career with science’ only few technology and ICT skills were considered necessary for ‘careers in science’. The students link ‘careers in science’ with personal attributes and social responsibilities more than ‘career with science’. On the other hand, ‘careers with science’ are related to sector-specific skills, technology and ICT literacy skills, collaboration and teamwork, creativity and innovation.
When considering the students’ perceptions of the required working life skills in different science-related careers, we concluded that students possess a lot of knowledge about different type of working life skills. However, they linked stereotypical skills and attributes to scientific careers. Therefore, it was decided that the following interventions should deal with this issue by introducing the key working life skills and other required competences of each scientific careers in focus of each intervention.

### 5.2 FIRST INTERVENTION: OLD PIPES FOUND


Before the first intervention, the teachers participated in a national planning meeting where the idea of career-based scenarios was introduced. In this meeting the teachers looked for science-related careers and industry near their schools. They found a major metal industry employer in the region, and their 7th grade curriculum included thermal expansion. Thus, the topic and content for the first scenario and intervention implemented in spring 2016 was decided. Now it was only about finding career(s) from the industry. The nature of this intervention is to pilot career-based scenarios with the teachers and students. As a career-based scenario the teachers showed a video about metal industry and after that they visited the local company (Table 4).
Table 4. Design hypotheses and instruction design in the first intervention

<table>
<thead>
<tr>
<th>Design hypotheses</th>
<th>Instruction design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot the idea of career-based scenario with familiar curriculum content. Teachers decided to enlarge their way of using scenarios with a visit to local company and use a problem related to the visit during inquiries.</td>
<td>Career-based scenario: PP-presentation about the company, questions for the visit, visit to careers presented in video and in the company: NC-machinist and Calibrator. Inquiries: Guided laboratory experiments. Inquiry is aimed to find help for industry workers.</td>
</tr>
</tbody>
</table>

During the tour they encountered and discussed with calibrator, NC-machinist and production engineer. In the next lesson the scenario continued with a PP-presentation about the company and two career stories: NC-machinist and calibrator. The scenario was followed by inquiries about thermal expansion. The students were asked to examine different pipes and decide what metal they were made of. From the industry visit some information were given why thermal expansion is so important but no straight link with curriculum topic and scientific issue were given. Therefore, school science and learning experiences left unconnected with the careers and the instruction was shattered. Moreover, the rest of the instruction followed a familiar structure for the teachers.

The teachers worked as a team designing and developing the instruction. They decided to enlarge their way of using scenario as a visit to local company. The teachers perceived that the visit could be something new for their scenario. Both teachers agreed on that more development and planning is needed in future scenarios to better enrich science teaching and learning through career-based scenarios and make good links between scenario, careers and inquiries so that the students could see the relations of the inquiries with the presented careers.

The students highly appreciated the visit outside the school. However, they were a little shy or confused to ask about the careers during the visit. Not least because of the safety factors, prohibited photographing and the industry environment. The students had mixed perceptions about the connection between careers and inquiry. Stories were not enough to link the visit, careers and working life with the inquiries. However, the students perceived that career of a calibrator introduced during the visit was more connected with thermal expansion than the story of a NC-machinist.

Both teachers agreed that more development and planning is needed in future scenarios and interventions to better enrich science teaching and learning through career-based scenarios and make good links between scenario, careers and inquiries so that the students could see the relations of the inquiries with the presented careers.
5.3 SECOND INTERVENTION: WATER (STUDY II)


This study aims to examine how career-related instruction effects on students’ career awareness and interest towards science topics and science learning. For this purpose, the instruction lessons are observed through the intervention and the students’ answer an instruction evaluation questionnaire. Descriptive analysis of the questionnaire and content analysis of observation notes is conducted to better understand the influence of the instruction in students’ interest, engagement and enjoyment in science learning. Teachers were planning the scenario before summer and had many new ideas of how to use the help of different professionals but the busy start of semester in autumn 2016 lead to re-design their old scenario which concerned inquiring the condition of a nearby lake (Table 5).

Table 5. Design hypotheses and instruction design in the second intervention

<table>
<thead>
<tr>
<th>Design hypotheses</th>
<th>Instruction design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-design an old scenario used for several years in the school to fit the career approach. Include links to working life skills throughout the intervention to promote students’ career awareness and possibilities to make links between school science and professional work.</td>
<td>Career-based scenario: A film made by previous students about the lake Mertajärvi in different seasons and PP-presentation with information about the history of the lake Mertajärvi and what have been done and by what professionals to the lake.</td>
</tr>
<tr>
<td></td>
<td>Career presentation: Health officer at the lake, chemists, biologists,</td>
</tr>
<tr>
<td></td>
<td>Inquiries, activities and their connection to scenario: PP presentation ended with research questions: In what condition is the water in the lake Mertajärvi? Is the water quality of the lake Mertajärvi suitable for swimming? Examine and find the facts and make a decision. The students carried out scientific inquiries.</td>
</tr>
</tbody>
</table>

The results indicate that students acquired new knowledge about science topic, careers and working life skills. The issue of water was not personally important or valuable for students, but they acknowledged that water-related issues are societal problems globally and locally. They also recognized the need for professionals and their responsibilities. Students recognized local scientific problems, but it might not be enough to maintain their interest and engagement in science learning if they do not perceive the topic and scientific careers personally relevant. Thus, career-related instruction could benefit from using the careers throughout the instruction. Furthermore, to promote students’ perceived interest and relevance towards science learning, career-related instruction should provide students with moderate amount of new knowledge and skills related with science topic. Moreover, linking this knowledge with variety of scientific careers to show the nature of these careers and links between school science and working life.
The observation results (Table 6) reveals that even though the lessons concentrated on students’ acquiring working methods and skills, there was also moderate amount of link to working life, careers and society. The amount of scientific work frustrated the students a bit, but after all the students’ interest, enjoyment and engagement during the intervention was mainly positive (24/32 observations related to interest).

Table 6. Categorization of observations in study II

<table>
<thead>
<tr>
<th>Categories</th>
<th>Number of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students’ working methods and skills</td>
<td>60</td>
</tr>
<tr>
<td>Reasoning and argumentation</td>
<td>21</td>
</tr>
<tr>
<td>Technology and instruments</td>
<td>13</td>
</tr>
<tr>
<td>Precision and caution</td>
<td>12</td>
</tr>
<tr>
<td>Instructions and time management</td>
<td>8</td>
</tr>
<tr>
<td>Notes and observations</td>
<td>6</td>
</tr>
<tr>
<td>Interaction</td>
<td>49</td>
</tr>
<tr>
<td>Collaboration and teamwork</td>
<td>18</td>
</tr>
<tr>
<td>Teacher-student</td>
<td>15</td>
</tr>
<tr>
<td>Student-student</td>
<td>11</td>
</tr>
<tr>
<td>Leading and guiding</td>
<td>5</td>
</tr>
<tr>
<td>Working life skills, careers and society</td>
<td>48</td>
</tr>
<tr>
<td>Working life skills</td>
<td>22</td>
</tr>
<tr>
<td>Careers</td>
<td>19</td>
</tr>
<tr>
<td>Society and public participation</td>
<td>7</td>
</tr>
<tr>
<td>Emotions, feelings and experiences</td>
<td>41</td>
</tr>
<tr>
<td>Frustration</td>
<td>16</td>
</tr>
<tr>
<td>Positive emotions</td>
<td>12</td>
</tr>
<tr>
<td>Negative emotions</td>
<td>8</td>
</tr>
<tr>
<td>Own experiences and empathy</td>
<td>5</td>
</tr>
<tr>
<td>Interest and engagement</td>
<td>32</td>
</tr>
<tr>
<td>Interest during inquiries and discussion panel</td>
<td>17</td>
</tr>
<tr>
<td>Interest during scenario</td>
<td>15</td>
</tr>
<tr>
<td>Engagement</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>243</td>
</tr>
</tbody>
</table>

As shown in the Table 7, 95 percent of the students perceived that they gained new knowledge about the topic (M=3.03; SD=0.49). However, the complexity of the inquiries and assignments during the intervention might have decrease the perceived practical usefulness of this knowledge to the students.
Table 7. The results of the instruction unit evaluation in study II. N=39

<table>
<thead>
<tr>
<th>Item (4-point Likert scale)</th>
<th>M</th>
<th>SD</th>
<th>agree (N)</th>
<th>disagree (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I gained new knowledge about the topic.</td>
<td>3.03</td>
<td>0.49</td>
<td>95 % (37)</td>
<td>5 % (2)</td>
</tr>
<tr>
<td>The knowledge I gained from the unit may be useful in the future.</td>
<td>2.54</td>
<td>0.72</td>
<td>56 % (22)</td>
<td>44 % (17)</td>
</tr>
<tr>
<td>I can use the knowledge acquired to solve problems in practice</td>
<td>2.49</td>
<td>0.60</td>
<td>54 % (21)</td>
<td>46 % (18)</td>
</tr>
<tr>
<td>The topic is important for me.</td>
<td>2.13</td>
<td>0.62</td>
<td>26 % (10)</td>
<td>74 % (28)</td>
</tr>
<tr>
<td>This unit enables me to understand local entrepreneurs and their operations</td>
<td>2.59</td>
<td>0.50</td>
<td>59 % (23)</td>
<td>41 % (16)</td>
</tr>
<tr>
<td>The topic raises my interest on studying science subjects</td>
<td>2.23</td>
<td>0.78</td>
<td>28 % (11)</td>
<td>72 % (28)</td>
</tr>
<tr>
<td>The topic is important for the world.</td>
<td>2.62</td>
<td>0.85</td>
<td>64 % (25)</td>
<td>36 % (14)</td>
</tr>
<tr>
<td>My future career may be connected with the topic.</td>
<td>1.85</td>
<td>0.63</td>
<td>13 % (5)</td>
<td>87 % (34)</td>
</tr>
<tr>
<td>I predict I will need to perform skills, learned in the unit, in my future career.</td>
<td>2.03</td>
<td>0.54</td>
<td>15 % (6)</td>
<td>85 % (33)</td>
</tr>
<tr>
<td>I predict I will need the science-related skills, learned in the unit, in my future career.</td>
<td>2.15</td>
<td>0.63</td>
<td>28 % (11)</td>
<td>72 % (28)</td>
</tr>
<tr>
<td>This unit described science-related problem significant to the society.</td>
<td>2.74</td>
<td>0.79</td>
<td>69 % (27)</td>
<td>31 % (12)</td>
</tr>
<tr>
<td>It was easy for me to relate with the scenario described in the beginning of the unit.</td>
<td>2.49</td>
<td>0.56</td>
<td>51 % (20)</td>
<td>49 % (19)</td>
</tr>
<tr>
<td>During the unit it was easy to study.</td>
<td>2.87</td>
<td>0.57</td>
<td>87 % (34)</td>
<td>13 % (5)</td>
</tr>
<tr>
<td>Working during the unit was pleasant.</td>
<td>2.74</td>
<td>0.55</td>
<td>74 % (29)</td>
<td>26 % (10)</td>
</tr>
<tr>
<td>I participated actively during the work.</td>
<td>2.85</td>
<td>0.54</td>
<td>87 % (34)</td>
<td>13 % (5)</td>
</tr>
<tr>
<td>I gained knowledge about careers new to me.</td>
<td>2.55</td>
<td>0.76</td>
<td>61 % (23)</td>
<td>39 % (15)</td>
</tr>
<tr>
<td>This unit helps me to understand the responsibility of the described careers.</td>
<td>2.67</td>
<td>0.66</td>
<td>67 % (26)</td>
<td>33 % (13)</td>
</tr>
<tr>
<td>I became interested of the described careers.</td>
<td>1.87</td>
<td>0.63</td>
<td>13 % (3)</td>
<td>87 % (20)</td>
</tr>
<tr>
<td>This unit helps me to understand what skills are needed in the described careers.</td>
<td>2.52</td>
<td>0.59</td>
<td>57 % (13)</td>
<td>43 % (10)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item (3-point Likert scale)</th>
<th>M</th>
<th>SD</th>
<th>agree (N)</th>
<th>neutral (N)</th>
<th>disagree (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find the topic of the unit interesting.</td>
<td>1.86</td>
<td>0.67</td>
<td>16 % (6)</td>
<td>54 % (20)</td>
<td>30 % (11)</td>
</tr>
<tr>
<td>I want to learn more about the topic</td>
<td>1.70</td>
<td>0.66</td>
<td>11 % (4)</td>
<td>48 % (18)</td>
<td>41 % (15)</td>
</tr>
</tbody>
</table>

Learning experiences were pleasant (M=2.74; SD=0.55) and studying easy (M=2.87; SD=0.57) during the intervention. In addition to the knowledge and skills, the students also learned about new careers to them and they understood the skills and responsibilities required in the career. The teachers included the careers and working life skills throughout the intervention. However, the students showed low interest towards the described career (M=1.87; SD=0.63) and perceived that their future career is maybe not connected with the topic. The students perceived the topic was not important for them but for the society (M=2.74; SD=0.79) and the world (M=2.62; SD=0.85).

It seems that a visit or a professional visitor in the lessons are a challenge and more attention is needed to make the careers and working life skills more visible to the students. Moreover, the instruction could benefit from using the careers, in addition to the scenario phase, throughout the intervention.
5.4 THIRD INTERVENTION: COAL TO TEETH (STUDY III)


This study investigated how teachers co-design career-related instruction together with researcher and science professional and included students’ respond to the implemented career-based scenario starting the career-related instruction. Teachers’ perceived ownership and agency are categorized using deductive content analysis with the help of previous research. In addition, descriptive analysis is conducted of students’ answers in the scenario evaluation research instrument (SERI; Kang et al., 2019). In the previous interventions and in the beginning of this one, teachers explained that integrating careers in science education is difficult and particularly linking them with the following inquiries (Table 8).

Table 8. Design hypotheses and instruction design in the third intervention

<table>
<thead>
<tr>
<th>Design hypotheses</th>
<th>Instruction design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career aspect should be maintained throughout the intervention by different kind of career-related activities. Intervention needs to be shorter to keep the whole instruction motivating for the students. It should combine information about health issues, chemistry and the career of a dentist and her explanations about the health issues with teeth. Personalized contact with the professional is needed to make it more relevant for students.</td>
<td>A film where a patient visits dentist and asks about the toothpaste with activated carbon. Dentist later requests the students to examine the safety and functionality of the toothpaste in teeth whitening. Video introduces the dentist's daily work with the patient. A film where a patient visits dentist and asks about the toothpaste with activated carbon. Dentist later requests the students to examine the safety and functionality of the toothpaste in teeth whitening.</td>
</tr>
</tbody>
</table>

In countries with high teacher autonomy, for example Finland, the teachers are not used to top-own approaches with instructional designs. With top-down approach teachers’ ownership and agency remain low. Results reveal that in this case teachers needed a change and it led them to co-design this educational innovation. Even though teachers’ mental and physical effort varied throughout the co-design process, their experienced ownership and agency remained high also at the end and after the implementation. In addition, students perceived the start of the instruction successful. Their perceived relevance varied between different dimensions: individual, social, vocational (knowledge gain), vocational (future aspirations).

As Table 9 shows, teachers supported the design and ideas of the instruction. Their ownership can also be interpreted from their mental and physical effort and how they identified with the instruction and highlighted the need for change. The teachers’ agency focused on their or other designers’ successes and failures, how the teachers accommodated with the instruction, their autonomy and feel of control throughout designing and implementing the instruction.
Table 9. Categorization of teachers’ perceptions about the instruction in the light of ownership and agency.

<table>
<thead>
<tr>
<th>Categories</th>
<th>n</th>
<th>Examples of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting the design or ideas</td>
<td>12</td>
<td>“It is good that someone else gives the tasks (to students) sometimes instead of a teacher.”, T1</td>
</tr>
<tr>
<td>Mental and physical effort</td>
<td>5</td>
<td>“It was easy and fun just to implement something pre-made. Made my job a little easier for once”, T2</td>
</tr>
<tr>
<td>Identifying with the instruction</td>
<td>5</td>
<td>“I have added this as one of my regularly implemented curriculum activities”, T2</td>
</tr>
<tr>
<td>Need for change</td>
<td>4</td>
<td>“Careers are hard to include in chemistry education.”, T1; “Something old with a new twist is needed”, T2</td>
</tr>
<tr>
<td>Agency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successes and failures</td>
<td>11</td>
<td>“Any mistakes in the scenario or inquiries were not anyone’s fault. It happens when you create or test something new.”, T1</td>
</tr>
<tr>
<td>Accommodation</td>
<td>6</td>
<td>“It was easy to implement and to go with the flow with the students.”, T1; “I did not see any reason not to follow the collaboratively designed learning unit.”, T2</td>
</tr>
<tr>
<td>Autonomy</td>
<td>4</td>
<td>“I think after all, we implemented the learning unit just the way we designed and wanted.”, T2</td>
</tr>
<tr>
<td>Feel of control</td>
<td>3</td>
<td>“The scenario was ready so late that it made me a little unsure of what was coming and how I would manage.”, T1; “After all, I did not see any reason for not following the designed learning unit. Of course, with minor changes I made along the way.”, T1</td>
</tr>
</tbody>
</table>

However, attending such a long design process, some aspects of ownership and agency such as control and autonomy over their own teaching can be lost. Conversely, other professionals’ viewpoints and new knowledge can be acquired.

The students’ answers in the questionnaire reveal that the career-based scenario starting the instruction was relevant for them personally and through social dimension (Table 10). This suggests that even though their current future aspiration vocational relevance is low now, career-related instruction provides them new knowledge or corrects existing stereotypes.

Table 10. Students’ scenario evaluation descriptive statistics. N=41.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance</td>
<td>2.33</td>
<td>0.77</td>
</tr>
<tr>
<td>Individual dimension</td>
<td>2.41</td>
<td>0.76</td>
</tr>
<tr>
<td>Societal dimension</td>
<td>2.36</td>
<td>0.71</td>
</tr>
<tr>
<td>Vocational dimension (knowledge gain)</td>
<td>2.75</td>
<td>0.62</td>
</tr>
<tr>
<td>Vocational dimension (future aspiration)</td>
<td>1.96</td>
<td>0.72</td>
</tr>
<tr>
<td>Interest</td>
<td>2.27</td>
<td>0.40</td>
</tr>
<tr>
<td>Scenario attributes</td>
<td>2.99</td>
<td>0.41</td>
</tr>
</tbody>
</table>
Furthermore, giving the students possibilities to make informed choices of careers later. Moreover, students appreciated the appearance of the scenario and open-ended questions reveal that the video interaction with the dentist was interesting for the students. Both students and teachers agreed that it was good that the dentist gives the problem instead of teacher. Teachers realised that it was good that the career of a dentist is somehow familiar for the students, but it would be good to expand the viewpoint from one career to a field of industry.

### 5.5 FOURTH INTERVENTION: BLACKOUT


In the fourth intervention in autumn 2018 the teachers combined the best CBL qualities of a career-based scenario and a career-related instruction of the first three intervention. Teachers were inspired to create their own scenario related to the local electricity company with the aid of the MultiCO researcher. First design was a visit to the power plant. However, even though the visit in the first intervention was a success, the teachers had problems linking the career presentation with the inquiries. Therefore, much more career-related approach was chosen, and the visit was decided to be only enriching teaching during the intervention (Table 11).

Table 11. Design hypotheses and instruction design in the fourth intervention

<table>
<thead>
<tr>
<th>Design hypotheses</th>
<th>Instruction design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Career-based scenario</strong></td>
<td>Students get a card with an item/device that needs electricity to function. They think how it helps them in their lives, not revealing the item to each other. Video about a city skyline blackout including local attraction. Students think what problems occur in relation with the earlier item/device and share these ideas within student pairs/groups/class.</td>
</tr>
<tr>
<td><strong>Career presentation</strong></td>
<td>Students completed a career circle by connecting career descriptions with career titles. Careers presented are power network designer, electrician, forester, staff manager, purchasing manager, production manager, customer service, process operator.</td>
</tr>
<tr>
<td><strong>Inquiries, activities and their connection to scenario</strong></td>
<td>The students are asked to pick one career from the career circle and write a job advertisement/career description during the intervention.</td>
</tr>
</tbody>
</table>

The career-based scenario included a game where students needed to think how different items/devices help them in their lives. The following blackout video activated the students and there were quiet discussions around the class. After the video, students needed to think about who is responsible of the situation and explain their items/devices to each other. Students were active with their discussion and questions about what kind of problems could occur during blackouts in their home,
home street and neighbourhood. Next, students combined different careers in the field of electricity with their descriptions. This part was difficult for the students. However, most of them liked his new approach to introduce multiple careers around the power grids. Furthermore, the students were asked to pick one career from the career circle and write a job advertisement during the intervention. This career-related activity continued through the scientific inquiries related with electricity. These career-related activities were designed to keep up the students’ motivation and the idea of using careers in science education and that scientific inquiries would not be the only active learning experience in science class.

Similarly, to the previous career-based scenarios (Table 12), the students acquired new knowledge and perceived the knowledge useful in their future and practical problem solving. The students’ awareness of careers, skills and responsibilities kept increasing from the previous intervention results as did their interest and perceived relevance.

Table 12. Students’ scenario evaluation descriptive statistics. N=36.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance</td>
<td>2.58</td>
<td>0.75</td>
</tr>
<tr>
<td>Individual dimension</td>
<td>2.57</td>
<td>0.69</td>
</tr>
<tr>
<td>Societal dimension</td>
<td>2.86</td>
<td>0.64</td>
</tr>
<tr>
<td>Vocational dimension (knowledge gain)</td>
<td>3.07</td>
<td>0.58</td>
</tr>
<tr>
<td>Vocational dimension (future aspiration)</td>
<td>2.14</td>
<td>0.72</td>
</tr>
<tr>
<td>Interest</td>
<td>2.33</td>
<td>0.81</td>
</tr>
<tr>
<td>Scenario attributes</td>
<td>2.87</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Teachers’ main challenge and concern about improving the transition from scenario to inquiries and other learning activities keeping in mind the career context was solved in this intervention by including multiple careers. This helped the teachers to pick up a career for different inquiry, teaching and learning phases. The link between multiple careers and the scenario topic was clear for students and they had more opportunities to choose a career to relate with. The idea of using industrial visit not as a scenario but as a complementing part of inquiries and learning was appreciated by teachers and students.
6 PERSPECTIVES ON CAREER-RELATED INSTRUCTION

Typically, design-based research in education sets a challenge to describe and refine theoretical or practical frameworks searching to offer solutions to educational problems (Cobb & Gravemeijer, 2008). This summary has so far described in the theoretical framework problems of students’ low career awareness in science and that students are not pursuing science studies or careers. Previous research on context-based learning (CBL) and using scenarios in science education is acknowledged and teachers’ role as educational designers is recognized. Empirical research on students’ perceptions of working life skills in science-related careers (study I) aligns with the previous research and propose a need for change in science education developmental work. This development work of career-related instruction through four interventions, including studies II and III, is provided in the previous chapter. The previous chapter also articulates successes and new challenges from the results of each intervention. The aim of this chapter is to provide connections and discussion between the problems and possibilities from previous research together with empirical research findings to build up career-related instruction in science education. Finally, implications and suggestions for further research will be discussed.

6.1 NEED FOR CHANGE

According to the findings of study I, students’ perceptions of working life skills were closely related to the categories in previous research on employers’ needs (Lim et al., 2016), workplace data (Jang, 2016), higher education students’ perceptions (Kallioinen, 2010), twenty-first-century skills (Binkley et al., 2012; Partnership for 21st Century Learning, 2019; Pellegrino & Hilton, 2012) and educational policies such as Finnish National Curriculum (FNBE, 2014). However, some variation is obvious and there was need for some new categories, for example personal attributes. Students also perceived the careers differently. According to them, careers with science are more creative, innovative and collaborative and need technology and ICT literacy. Conversely, careers in science are sector-specific knowledge and skills oriented. This suggests that although the students have a great deal of knowledge about working life skills, they might have bias and stereotypes of science-related careers. They might even lack knowledge (cf. Cleaves, 2005) about the careers which they fill with general attributes they are aware. The lack of career awareness affects their aspirations in science studies and careers (Archer et al., 2014). The perceived difference between the careers might end up students choosing careers with science instead careers in science. To promote the careers in science the students need more information about the true required competences of these careers, and possibilities to relate their own existing competences with these demands. Students perceptions of working life skills help designing novel instructions that provide them with the possibilities of lining up what is the value of their current knowledge and skills to make informed decisions about their future studies and careers. Thus, this dissertation argues that using career-
related instruction continuously, it can have more longer lasting and meaningful influence on students’ study choices and career aspirations later in their life.

Students need more information about the careers and career guidance should be integrated into subject teaching instead of being a separate part of primary and secondary education. Therefore, it is necessary to make changes in science education so it could introduce scientific careers more accurately to the students in authentic environments and contexts. Study II results reveal that if we can understand the students’ individual interests and connect those with the right science topics, content and careers, we can enhance their engagement in science. Moreover, we should concentrate on promoting students’ personal values and perceived vocational relevance. In addition, the results of study III confirm that science teachers acknowledge this challenge and are in need for change. However, they need help in finding proper school-industry/community partnerships. It takes time and other resources from teachers to design new instructions from scratch but once they start to make these partnerships, it becomes easier to approach new professionals and partnerships in future.

### 6.2 CAREER-RELATED INSTRUCTION

All four interventions in this DBR were different in topics, careers, scenarios and inquiries, yet they all followed similar principles of design and activities. Background information from study I and results from interventions together with students and teachers’ perceptions reshaped the instruction model, particularly how working life skills and careers should be introduced. To answer the research objectives, this chapter presents the general instruction model of the career-related instruction in science education. This career-related instruction model (Figure 6) represents a framework of using scientific careers as context for scenarios and instruction used in science education and how career-based scenarios could be implemented as starting point for the instruction. The model consists of three parts: design principles, learning experiences and outcomes which the following corresponding chapters deal with.
6.2.1 Design principles and practical prerequisites

The four presented design principles (Figure 6) are the key elements to guide through the rest of designing and using the instruction in science education. These principles are derived from previous research, design hypotheses of the interventions and evaluation of the interventions with the teachers. Other principles are possible to be used along these four, but SSIs, curriculum link, global challenges and science-related careers should be addressed in career-related instruction. The instruction promotes strong connection and participation with local industry and society through relevant SSI approaches (Sadler, 2011). These DBR results suggest that this instruction model fits well the science education in Finland, where long, interdisciplinary and extensive instructions are possible to implement (FNBE, 2014). Hence, career-related instruction can be part of the curriculum as suggested by Andersen and Ward (2014) and Holmegaard et al. (2014). In addition, these design principles in career-related instruction creates learning that enables students’ interaction with STEM field professionals. These interactions make it possible to increase their awareness of possible careers (cf. Maltese & Tai, 2011). Entrepreneurial perspective of careers and working life skills should also be emphasized. In addition, using multiple careers and professionals from both genders help the students to see connections between the careers in same field and to relate themselves with at least some of the careers. This way the career-related instruction also corrects all kinds of stereotypes that still exist.

Figure 6. Career-related instruction model in science education.
about the careers in science (Miller, Eagly & Linne, 2015) and the required working life skills (Salonen et al., 2019).

The most fruitful way of designing the career-related instruction is co-designing it with peer teachers, students, professional and other stakeholders. This co-design succeeds when teachers are open for the ideas of innovative instructions, reflect the successes and failures throughout the process, feel the need for change and have enough autonomy and control over the implementation. The critical prerequisites for successful career-related instruction are enough resources such as time, materials, peer support and access to experts.

6.2.2 Career-based scenario and other learning experiences

The intervention results presented in this dissertation together with similar attempts in science education research suggest that career-related learning experiences start with the career-based scenario, which can be almost in any form. However, it needs to include at least two settings. Firstly, it sets a problem for the future learning. It can be a given problem, or an open problem connected with the topic. Furthermore, when students are exposed to this kind of instruction regularly, they can be responsible of finding and defining the problems. Secondly, career setting is included. Careers are introduced for example with stories, videos, visits, pictures, voices and interviews. Moreover, career setting gives the scenario a context from real working life. Two other settings: inquiry setting, and action setting are optional and can be outside the scenario. Inquiry setting gives the students guidelines for the related scientific inquiries. Action setting lead the students towards other activities, in this instruction model, career-related activities. All activities are bridged and make each other more relevant by showing the students how science can be useful outside school or specific topics and contents (Andersen & Ward, 2014; Broman, Bernholt & Parchman, 2018; Cigdemogly & Geban, 2015).

The career-related instruction learning experiences in science has four major conditions, which can be met with good practice and use of the instruction. These challenges in mind helps to design and implement the instruction in a successful way to promote students’ interest and increase career awareness. Firstly, the length of career-based scenario and the whole instruction must be adequate. Short scenarios raise the interest but enables the students move forward to motivating inquiries and activities. However, the instruction as whole needs time to have several links between inquiries, multiple careers and socio-scientific issues. Otherwise, the important contexts of science-related careers, opportunities to increase students’ career awareness, and knowledge of working life skills might be lost.

Secondly, choosing the careers might be difficult so they would fit the topic, inquiries, other activities and students’ interests. Therefore, the best choice is to use multiple careers with shared context and choose the career setting so that it is not only informative but also interesting and motivating in many ways for the students. Thus, students can find different levels of contexts relevant with their lives and interest (Bennett et al., 2007). Such contexts should include something old but with a new twist. The new twists can be introduced with activities inside the career-based scenario. Students would not only follow the scenario, but also be active participant in it. This idea leads us to the third challenge.
Career-related activities or actions are needed throughout the instruction instead of only in the beginning or in the end. These activities are in a key role if we want the students to see the relations between science, inquiries, local and global environments, industry and themselves. In addition, career-related activities, for example interaction with real professionals, visits and career assignments can increase the students’ awareness of needed skills and responsibilities in the science-related careers. These activities help teachers to plan instructions with relations to everyday life and emphasize the link between science and society (cf. Christidou, 2011; Walper et al., 2014).

Lastly, all learning experiences need to be interconnected. Thus, the students can more easily recognize the connections between school science and practical life to stabilize or increase their interest in science (Krapp & Prenzel, 2011).

6.2.3 Learning, attitudinal and career aspiration outcomes

Outcomes in the instruction are the students’ scientific results from their inquiries, their acquired knowledge and skills, and science-related career awareness. The most successful instructions would include utilizations of students’ inquiry results and conclusions for the benefit of industry, society and the environment. This was the case for example with the water intervention in this dissertation. The health inspector was very keen to work with the students. It is obvious that students learn knowledge and skills by doing scientific inquiries and career-related activities, but they all need a context to link with. Therefore, the instruction model suggests that most of the information about careers are included at the beginning. Amount of knowledge and exercise of the working life skills increases during the learning. Together the elements of the career-related instruction help the students to make informed decisions and promote their science relevance and interest.

The career-related instruction offers a solid foundation to change the way science education has introduced, or not introduced at all, the scientific careers and entrepreneurship. We acknowledge that the instruction still has both challenges and possibilities. It is challenging to use the design principles to find the most suitable combination of topics and careers. Moreover, connecting the topics and careers with scientific inquiries, career-related activities and expected learning outcomes such as knowledge and skills can also be challenging. On the other hand, the same challenges that occur are the greatest possibilities the instruction can offer when educators win them.

6.3 IMPLICATIONS AND SUGGESTIONS FOR FUTURE DIRECTIONS

This dissertation has presented a need for change in promoting scientific careers and that both teachers and students are need of accurate information and solutions for acquiring this knowledge. To overcome this need for change, the teachers and research team found a good balance between top-down and bottom-up approaches in designing career-related instruction in science education. With the career-related instruction in science education students can acquire accurate information about STEM careers, and skills and responsibilities in these careers. The instruction aims
to promote scientific careers and increase the number of students to pursue science studies and careers. However, as importantly as the career-related instruction attracts to scientific careers it can also correct false hopes of future careers.

Our recommendation is that such instruction should be used more often in science education and with younger and older students as well. More often as there are plenty of careers or fields, which cannot all be presented in once-a-year instructions. These instructions help younger students to gain correct information of science-related careers and help them to develop informed career aspirations and choices. Older students, in high school, need information to correct stereotypes. They are also in a critical phase when they are choosing their future studies and careers. Moreover, the career-related instruction should acknowledge the entrepreneurship in science and the entrepreneurial skills along other working life skills as essential part of science education.

Co-design processes might need more effort than regular science teaching planning. However, in co-designing partnerships effective use of different designer roles can result benefits for everyone. Moreover, once designed instructions are useful time after time. Although, as DBR and co-design posits the design might not be mature ever. Hence, the career-related instruction as it is, is easy to integrate in to regular and normal science teaching yet open for endless development. It is novel and flexible but does not forget traditional scientific knowledge and skills. Thus, it provides a low threshold to adopt the instruction in both pre-service and in-service teacher training.

The career-related instruction is an instructional framework developed in an authentic practice with teachers and researchers, and empirically based development with the available data. It posits possible answers but also new hypotheses in promoting students’ scientific career awareness and increase their interest to pursue in science studies and careers. At this point, we need to acknowledge that any models proposed in DBR are not considered as final and perfect versions. The instruction model is still “under construction” and it needs to be further developed with different contexts. Moreover, testing the career-related instruction outside science education could give fruitful insights of more general usability and perhaps widen it. The next natural step in this DBR process is to enlarge and disseminate the innovation wider and study the longitudinal effect of the instruction in students’ career awareness and aspirations. Moreover, this instructional model could be utilized to different school subjects and fields of education and work life. For example, the model would also be well suited for technology, engineering and design education which are rapidly changing fields and raise new career opportunities every day.

As research methods develop along the instructional innovations in DBR, it is worth noting that students’ awareness of careers should be measured with variety of instruments and variables. Methodologically examining students’ study and career choices is difficult because we should encounter and influence on their science career awareness and the attractiveness of science in early school years, but the effect could not be measured for several years. Therefore, longer longitudinal studies are needed to create a students’ path towards science studies and careers.
REFERENCES


Ainley, M., & Ainley, J., (2011), Student engagement with science in early adolescence: The contribution of enjoyment to students’ continuing interest in learning about science. Contemporary Educational Psychology, 36, 4-12. DOI: 10.1016/j.edpsych.2010.08.001.


Avalos, B. (2010). Teacher professional development in Teaching and Teacher Education over ten years. Teaching and Teacher Education, 27, 10-20. DOI: 10.1016/j.tate.2010.08.007


Cummings, R., Phillips, R., Tilbrook, R., & Lowe, K. (2005). Middle-Out Approaches to Reform of University Teaching and Learning: Champions striding between the top-down and bottom-up approaches. The International Review of Research in Open and Distributed Learning, 6(1). DOI: 0.19173/irrodl.v6i1.224


ORIGINAL PUBLICATIONS (I – III)

STUDY I

STUDY II

STUDY III
STUDY I
Secondary school students' perceptions of working life skills in science-related careers

Anssi Salonen, Anu Hartikainen-Ahia, Jonathan Hense, Annette Scheersoi & Tuula Keinonen


To link to this article: https://doi.org/10.1080/09500693.2017.1330575

© 2017 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

Published online: 25 May 2017.

Submit your article to this journal

Article views: 3293

View related articles

View Crossmark data

Citing articles: 6 View citing articles
Secondary school students’ perceptions of working life skills in science-related careers

Anssi Salonen, Anu Hartikainen-Ahia, Jonathan Hense, Annette Scheers and Tuula Keinonen

Philosophical Faculty, School of Applied Educational Science and Teacher Education, University of Eastern Finland, Joensuu, Finland; Fachdidaktik Biologie, University of Bonn, Bonn, Germany

ABSTRACT

School students demonstrate a lack of interest in choosing science studies and science-related careers. To better understand the underlying reasons, this study aims to examine secondary school students’ perceptions of working life skills and how these perceptions relate to the skills of the twenty-first century. The participants in this study were 144 Finnish 7th graders (aged 13–14 years). Using a questionnaire and qualitative content analysis, we examined their perceptions of working life skills in ‘careers in science’ and ‘careers with science’. Results reveal that although students have a great deal of knowledge about working life skills, it is often just stereotyped. Sector-specific knowledge and skills were highlighted in particular but skills related to society, organisation, time and higher order thinking, were often omitted. Results also indicate that students do not associate ‘careers in science’ with creativity, innovation, collaboration or technology and ICT skills. Conversely, according to the students, these careers demand more sector-specific knowledge and responsibility than ‘careers with science’. We conclude that students need more wide-ranging information about scientific careers and the competencies demanded; such information can be acquired by e.g. interacting with professionals and their real working life problems.

ARTICLE HISTORY

Received 2 December 2016
Accepted 10 May 2017

KEYWORDS

Working life skills; science careers; secondary school students; science education; twenty-first-century skills

Introduction

Europe is currently experiencing many scientific challenges that are related to energy, water, waste, climate change, food, health and transport issues, thus the need for more scientists to face these challenges is emphasised. People recognise the major social importance of science careers (Kiljunen, 2013; National Science Board, 2014) but students lack interest in choosing science studies and careers (Organisation for Economic Co-operation and Development, 2007). The reasons for this can be found in the lack of knowledge, and negative attitudes and perceptions about science and scientific careers (Archer, DeWitt, & Dillon, 2014). These conceptions about scientific careers seem to be stable at least through
several years of adolescence, and students have a strong perception that scientific careers are not particularly creative and do not involve much interaction with others (Masnick, Stavros Valenti, Cox, & Osman, 2010).

Students who choose not to take science studies, imagine science careers as having no opportunities for future self-development and positions of influence (Holmegaard, Madsen, & Ulriksen, 2014). Negative conceptions dominate. Maltese and Tai (2011) found that middle-grade students are not aware of career options, and few students indicated knowing professionals who are actively working in STEM fields. Furthermore, Cleaves (2005) found that two factors influence students’ future science career choices; the first being a lack of knowledge about science occupations and science work and the second, students’ self-perception that underestimates their science abilities. Providing students with support, information and advice about career options and educational requirements, seems to be critical for increasing the utility value of school science. Information about STEM careers needs to be part of the science curricula (Andersen & Ward, 2014).

Science subjects in school have an impact on students’ future career choices (Lavonen et al., 2008), as they must provide students with the skills to face the demands of challenging employment and working life (Bybee & Fuchs, 2006). Science education should include not only knowledge of science content and how science works, but also cover the diversity of science careers and their value (Osborne & Dillon, 2008). The number of students choosing STEM studies and careers can be increased by arousing greater student awareness and providing more accurate perceptions of science (Osborne & Collins, 2001) and technology (DiGironimo, 2011) careers. Students with early awareness (Osborne & Collins, 2001) and personal connections to these careers (Gebbels, Evans, & Delany, 2011; Tai, Liu, Maltese, & Fan, 2006) can develop informed decisions about these careers.

Education aims to provide students with the proper knowledge and skills needed to manage in their future careers. Skills needed in the twenty-first century (Binkley et al., 2012; P21, 2015; Pellegrino & Hilton, 2012) are studied widely, and graduates (Lee & Fang, 2008; Stenström, 2006), employers, employees and teachers are heard about the working life skills needed in science and technology careers (Jang, 2016; Kallioinen, 2010; Lim, Lee, Yap, & Ling, 2016). This paper focuses on what kind of working life skills secondary school students link to science-related careers. The study offers a background to the overall goal of developing teaching, with the aim of promoting young people to choose scientific studies and careers.

Literature uses many different terms to describe working life skills; job skills, key skills (Jones, 2009), employability skills (Rosenberg, Heimler, & Morote, 2012), transferable skills (Pellegrino & Hilton, 2012), generic skills or generic competences (Pešaković, Flogie, & Aberšek, 2014). The skills and knowledge that are usually acquired in formal education are seen as being transferable between careers and duties, although the use of these skills might be totally different in each working environment. There is also a lack of information among academics, industrialists and students, regarding the understanding of these skills (Pellegrino & Hilton, 2012).

When reviewing different twenty-first-century frameworks, Binkley et al. (2012) found 10 skills, namely creativity and innovation; critical thinking, problem-solving, decision-making; learning to learn, metacognition; communication; collaboration (teamwork); information literacy; ICT literacy; citizenship – local and global; life and career; and
personal and social responsibility. They grouped these skills into four categories: Ways of thinking, Ways of working, Tools for working and Living in the world. They developed three categories within the skill groups: knowledge, skills and attitudes/values/ethics and referred to them as KSAVE. Knowledge includes all the specific knowledge or understanding for each of the 10 skills. Skills are the abilities and processes that are developed in students and are a focus for learning. Attitudes, values and ethics describe behaviour and aptitudes in relation to the 10 skills.

Jang (2016) recently studied data from U.S. workplaces which stated the skills required in STEM careers, and found that these appear to be: higher order thinking skills, complex problem-solving, as well as judgement and decision-making. Logic and reasoning are skills to be used in the evaluation of alternative solutions. Literacy skills such as reading comprehension, listening, speaking and writing skills, are required to understand and deliver work-related information. System, organisational analysis and management skills, are important in order to increase performance relating to the system’s goals. Collaboration and teamwork skills are frequently needed with social skills and instructional skills. Competencies related to time management and the updating of knowledge, are needed to well manage both one’s own time and that of others, as well as in the selection and use of appropriate methods when learning or teaching new things. Jang (2016) also found that compared to the required working life skills in STEM careers, twenty-first-century skill frameworks lack the skills related to time, resource, knowledge management and systems. Conversely, STEM graduates are lacking in non-scientific and non-technical skills (Kramer, Tallant, Goldberger, & Lund, 2014) such as writing and oral skills, project management, teamwork, problem-solving and critical thinking (Lee & Fang, 2008; Radermacher & Walia, 2013).

Employers need employees who can adapt and act quickly in the ever-changing world of work. Therefore, for their part, European employers prefer team working skills, sector-specific skills, communication skills, computer skills, an ability to adapt to and act in new situations, good reading and writing skills, analytical and problem-solving skills, planning and organisational skills, and decision-making skills (European Commission, 2010). Contrary to the U.S. in all fields, the large majority (89%) of European employers agree that those higher education graduates taken into employment, had the skills required to work in their company (European Commission, 2010). Employers were mostly satisfied with the graduates’ computer skills, reading/writing skills, teamwork skills and sector-specific skills; they were less satisfied with the graduates’ planning and organisational skills, decision-making skills and foreign language skills.

The previous National Core Curriculum of Finland introduced into schools in 2006, defined career advice as mainly being a part of student counselling and working life practice (Finnish National Board of Education [FNBE], 2004). Some of the working life skills were included in cross-curricular themes that were covered in all school subjects. Reform of the National Core Curriculum makes two important upgrades to this. Firstly, the new Core Curriculum taken into practice in the autumn of 2016, introduces seven broad-based competences that are more skill-oriented than person-oriented: Competence in thinking and learning to learn; Competence in cultural interaction and expression; Looking after oneself and life skills; Multiliteracy; Competence in Information and Communication Technology (ICT); Working life skills and entrepreneurship; Competence in participation, empowerment and responsibility (FNBE, 2014). These competences mix knowledge, skills, values, attitudes and determination. Secondly, there are additions to
the subject-specific syllabuses about working life and careers in each subject area. In geography studies, for instance, students are introduced to the skills and knowledge of geography needed in working life and in different sectors of society. Other science subjects have similar specifications.

For this study, science education presented students with various science-related careers, after which students’ perceptions of these careers were examined. It was aimed to ascertain what kind of skills students link to these careers and consider to be most important, giving educators a better understanding as to how science studies and careers in science education can be promoted more efficiently. This study answers the following research questions:

What are the students’ perceptions of working life skills in science-related careers?
How do the perceptions differ when considering various science-related careers?

**Method**

The context of this study is the EU project ‘Promoting Youth Scientific Career Awareness and its Attractiveness through Multi-Stakeholder Co-operation’ (MultiCO). The MultiCO Project’s aims are to promote students’ awareness and interest in science career paths and working life skills. This study forms a part of the pre-phase of design-based research, which is implemented in the MultiCO project. The design-based research combines research and practice to develop theoretical frames and practical patterns (Wang & Hannafin, 2005). The aim of this study was to ascertain what kind of skills students consider to be necessary and important in science-related careers. The participants were 144 Finnish 7th graders (aged 13–14 years) from three different schools in Eastern Finland. During this study, the participants worked in small groups of two to three persons. Each group discussed the career pairs introduced in Table 1 and the abilities needed in these careers. The careers were chosen to cover all STEM areas. Careers in scientific fields and careers working only with science topics are considered as ‘careers in science’. In ‘careers with science’, scientific knowledge or skills are used as a tool or source for knowledge and skills.

The teacher introduced the careers, describing those that were strange and unfamiliar to the students, but not mentioning the skills or abilities necessary to the careers in question. The students were asked firstly to discuss the given science-related careers in small groups, and then using a questionnaire, to write down all the skills that in their opinion were needed for each career. Lastly, they were asked to choose from the list, what in their opinion were the three most important skills. The students were given help with difficult careers, but care was taken not to mention the skills needed in any particular career.

**Table 1.** Career pairs used in the data collection.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Chemist</th>
<th>Air traffic controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 2</td>
<td>Pharmacist</td>
<td>Software designer</td>
</tr>
<tr>
<td>Group 3</td>
<td>Pathologist</td>
<td>Production planner (food industry)</td>
</tr>
<tr>
<td>Group 4</td>
<td>Meteorologist</td>
<td>Nurse</td>
</tr>
<tr>
<td>Group 5</td>
<td>Geneticist</td>
<td>Horticulturalist</td>
</tr>
<tr>
<td>Group 6</td>
<td>Zoologist</td>
<td>Mechatronics mechanic</td>
</tr>
</tbody>
</table>
Nevertheless, the teacher’s description and help with unfamiliar and difficult careers might have had a minor influence on the students’ answers. The teacher’s introduction and the group discussions took approximately 45 minutes in total.

In addition to the questionnaire, recordings were made of the small group discussions. Multiple data sources ensured the method triangulation (Patton, 1999); different data collection provided a backup if the responses were unclear or something was missing. In addition, reliability was enhanced with analysis triangulation (Patton, 1999); in the first phase, two researchers analysed the data separately, ending up with a similar categorisation and analysis of the data that ensured the reliability of further analysis. The responses in the questionnaire acted as the primary data and the recordings were used to clarify statements and to acquire additional information.

Data were analysed using content analysis. The analysis included two main phases: the preparation phase and the organising phase (cf. Elo & Kyngäs, 2008). In the preparation phase, all the questionnaires and records were marked with codes and transcribed. All the data were read through and a decision on analysis was taken based on the data itself. Since the data were mainly a list of skills, there was no need for open coding and it was decided that all the skills mentioned were used as analysis units, providing a total of 519 meaning units. Transcriptions were used directly as coding sheets and the skills were freely categorised and grouped. After using the inductive approach of the content analysis process, a deductive approach as an unconstrained analysis matrix based on Binkley et al. (2012) was used to conceptualise categories, and some categories were used as they are in the analysis matrix. An unconstrained analysis matrix allows the creation of new categories within its bounds; it is possible to choose those aspects that fit into the categorisation and use those that do not to create one’s own concepts or models, based on the principles of inductive content analysis (cf. Elo & Kyngäs, 2008).

The autonomy of the participant was respected; participation was voluntary, based on consent given by the students themselves. Consent was also asked from the parents or their guardians, teachers, schools and/or school administrators. No additional ethical review was needed from the Ethical Council as the study was part of the school’s normal activities. Privacy and data protection were taken into account; anonymity of the participants was secured by collecting data anonymously; the data were then made available only for the use of the research group.

Results

Working life skills mentioned by the students

The working life skills mentioned by the students were firstly grouped into 12 skill categories, and then into 4 main categories: Tools for working, Ways of working, Ways of thinking and Living in the world (cf. Binkley et al., 2012). Each skill category was further developed into various sub-categories shown in Table 2. The numbers shown in the sub-categories refer to how many times the students mentioned those particular skills.

The students pointed out that a large part of the Tools for working skills are needed in all of the careers especially sector-specific knowledge and skills, and were of the opinion that the sector-specific knowledge as the most needed category in science-related careers. Students’ perceptions of sector-specific knowledge were centred on school subjects, science or
general knowledge. However, they assumed that more specific knowledge is needed; for example, knowledge of anatomy, electricity, cells, genes, climate and bacteria. Sector-specific skills included scientific and research skills, manual and technical skills, practical skills, design and planning skills, as well as logical skills. Most of the student groups mentioned only a few technology and ICT literacy skills but they regarded these to be obligatory in almost every career.

The Ways of working skills were strongly linked with personal attributes. Students mentioned 20 different mental or physical attributes and self-control skills and pointed out that persons working in science-related careers need specific physical attributes; sharp senses such as sight, hearing and touch as well as a steady hand in their work. Closer analysis of the communication and collaboration skills was impeded due to the students’ generalisation in their statements, and it was impossible to obtain a precise description of attributes such as language skills, getting along with people and social skills. Nevertheless, these skills were linked with most of the science-related careers. Furthermore, students associated getting along with people and social skills, to collaboration and teamwork, although they did not emphasise working together as an important skill, as only one reference to co-operative skills was related to teamwork.

Students considered persons working in science-related careers as having a certain Mindset to help them manage. Ways of thinking were linked with a positive and
determined attitude, which was regarded as being necessary in science-related careers; liking one’s own profession and being interested in science and nature were also considered a necessity. In addition to a specific Mindset, higher order thinking skills were highlighted and mainly linked to problem-solving; these were only marginally linked to creativity or innovation skills.

Living in the world connected students’ perceptions of working life skills with society at large; they assumed personal and social responsibility skills to be necessary in careers which in some way affect human or animal well-being (air traffic controller, chemist, pathologist, pharmacist, production planner and zoologist).

**Working life skills in ‘careers in science’ and ‘careers with science’**

In general, the students highlighted the importance of Tools for working, especially sector-specific knowledge and sector-specific skills. Figure 1 presents the quantity distribution in the dataset of the main categories and the skill categories, between ‘careers in science’ and ‘careers with science’. Students mainly associated scientific and research skills such as diagnostics, fieldwork, forecasting and measuring skills with ‘careers in science’, but manual, technical or practical skills with both ‘careers in science’ and ‘careers with science’.

The Ways of working -category includes personal attributes. In this category, students described what kind of person or what kind of physical attributes or qualities are needed in a particular career. Collaboration, teamwork and communication skills were considered as being needed to some extent in most of the careers. Ways of thinking were pointed out as

![Figure 1](image.png)

**Figure 1.** Distribution of the main categories and skill categories in the dataset.
being necessary in science-related careers, but a specific Mindset was mainly highlighted rather than higher order thinking skills. Living in the world skills were linked only with a few careers, usually referring to responsibilities and confidence in other people and a person’s own safety.

Some variation becomes obvious in the students’ perceptions of working life skills, when comparing the skills mentioned between ‘careers in science’ and ‘careers with science’ (Figure 1). Students linked ‘careers in science’ more with sector-specific knowledge, personal attributes and personal and social responsibilities. On the other hand, they perceived ‘careers with science’ to be more closely related to sector-specific skills, technology and ICT literacy skills, collaboration and teamwork, creativity and innovation. However, comparing both the main categories and the skill categories is not enough to provide detailed information on the variation with which the students linked working life skills in each career, and which skills they regard to be most important for each career. The students’ perceptions of working life skills involved in some of the science-related career pairs are shown in Figures 2 and 3. Skills listed under the skill categories are the working life skills chosen as being the most important for each ‘career in science’. The students pointed out that a chemist (Figure 2) needs chemistry, knowledge and the properties of matter, mathematics and 10 other sector-specific knowledge skills; also scientific and research skills are needed to cope in such a career. A chemist’s career is one needing most of the skills relating to Ways of thinking, especially problem-solving skills. Although the students pointed out that chemists do not need much communication or social skills, they still need to get along with people. According to the

![Figure 2](image_url)  
Figure 2. The students’ perceptions of working life skills linked with the careers of a chemist and an air traffic controller.
students’ perceptions, a chemist has a distinct personal and social responsibility, since 9 out of 21 overall references in the category were linked to the career in this profession.

Data collection revealed that the chemist’s career was perceived as a ‘career with science’ in contrast to that of the air traffic controller. Students assumed that rather than sector-specific knowledge, the air traffic controller needs more personal attributes, and did not link as much sector-specific knowledge with the air traffic controller as with the chemist. Problem-solving skills linked with the air traffic controller included more perceptive and observation skills compared to the chemist’s reasoning and skills of application.

According to the students, a good memory and being systematic are the only Ways of thinking skills pharmacists (Figure 3) need. In addition, they felt that pharmacists neither need problem-solving skills nor sector-specific skills, but instead, they need lots of knowledge from a variety of fields. However, social and communication skills were regarded as being equally important for a chemist and a pharmacist. Even though both careers involved personal and social responsibility, students linked more personal responsibilities such as safety at work and health care with the chemist, but not with the pharmacist.

Skills linked with careers of the software designer (Figure 3) and the pharmacist, can be taken as an example of findings that students generally associated technology and ICT literacy skills more with ‘careers with science’ than ‘careers in science’. Additionally, students associated the software designer more closely with creativity and innovation skills than the pharmacist, (or any ‘career in science’) but linked less sector-specific knowledge with the software designer.
To summarise, careers that aroused the highest association with sector-specific knowledge were mostly ‘careers in science’: the meteorologist and geneticist receiving 27 references, the zoologist 24, and the chemist and pathologist 21. Students also most frequently chose these skills as being the most important in ‘careers in science’. As assumed from the students’ responses, with the exception of the meteorologist, only a few technology and ICT literacy skills were considered to be necessary in ‘careers in science’. Students generally pointed out that personal attributes play a large part in working life skills; ‘careers in science’ demanding at least three different personal attributes. ‘Careers in science’ were characterised more by personal attributes than ‘careers with science’; moreover, positive attitudes and interests related to both one’s own profession and science, were considered necessary to succeed in ‘careers in science’, especially in the careers of a chemist and zoologist. Students equally associated communication skills with ‘careers with science’ and ‘careers in science’, but collaboration and teamwork were slightly more connected to ‘careers with science’. At least one problem-solving skill was linked with every career, except for that of the pharmacist. Students pointed out that a chemist needs the most complex higher order thinking skills. From the data analysed, Living in the world skills were not regarded as generally being important and these skills were linked more with ‘careers in science’.

Discussion

In this paper, we have identified and categorised the working life skills that students perceived to be necessary in science-related careers. These results indicate that students associate working life skills in science-related careers with a large part of Tools for working, especially sector-specific knowledge and skills. They also expressed the necessity for multidisciplinary knowledge in many careers. Almost half of the sector-specific knowledge was based on references to school subjects, hence it seems that students perceive knowledge acquired from formal education as being important for working life. This finding supports a previous study concerning school science subjects’ impact on students’ future career choices (Lavonen et al., 2008). Thus, science education should start introducing information about science-related careers already during the early stages of primary school (cf. Andersen & Ward, 2014).

Students’ responses that were related to sector-specific knowledge and skills, were more detailed in this study than in previous ones (Binkley et al., 2012; Pellegrino & Hilton, 2012) and more highlighted than in the study by (Jang, 2016). Although students rarely mentioned thinking skills such as reasoning and information evaluation, their responses align with European employers’ views that sector-specific knowledge and skills are important in future careers (European Commission, 2010); thus, it can be stated that these skills need to be promoted in science education. Students did not highlight the importance of technology and ICT literacy in the same way as in previous studies (cf. Binkley et al., 2012; P21, 2015; Pellegrino & Hilton, 2012) which may be due to the fact that the students in this study represent a new generation of digital natives, to whom ICT skills are self-evident and not a specific working life skill.

It should be noted that in addition to sector-specific knowledge and skills, students perceived personal attributes as being important for science-related careers, highlighting the necessity for precision and mental awareness. Even though communicating and team
working in a multicultural working environment has increased and is seen as being important in twenty-first-century skills (Binkley et al., 2012; P21, 2015; Pellegrino & Hilton, 2012) and STEM careers (Jang, 2016; Lim et al., 2016), students linked collaboration and teamwork skills with very few science-related careers.

Thinking skills were thought to be equally important both in 'careers in science' and in 'careers with science' (cf. Jang, 2016). Our results suggest that students perceive thinking skills through Mindsets, emphasising more personal thinking and outlook than higher order thinking skills such as critical thinking, which industrial employers expect of the graduates (Lee & Fang, 2008; Radermacher & Walia, 2013) and which can be promoted through science education (Bybee & Fuchs, 2006). However, this would not automatically change the students’ ideas about working life skills. Students pointed out that at least some phases of a complex problem-solving process are necessary in science-related careers which align with the study by Masnick et al. (2010) finding that students link creativity and innovation with few 'careers in science'.

Even though some social and personal responsibility skills were mentioned, civil and society skills such as citizenship, life and career skills were not linked with science-related careers. This finding confirms the view that science education should use the opportunity to promote the importance of science-related careers in society (Osborne & Dillon, 2008). Although the current distribution of lessons in Finnish basic education includes two hours of social studies in grades 4–6 with the aim of emphasising civic knowledge at an earlier stage than before (FNBE, 2014), the lack of society skills in the responses might demonstrate that 7th graders are perhaps not active or interested in society or, despite being aware of these actions and skills they do not link them with working life skills. In addition, students rarely mentioned links to entrepreneurship even though the previous Finnish National Curriculum introduced a cross-curricular theme of participatory citizenship and entrepreneurship (FNBE, 2004).

Some of the careers, pathologist, production planner, geneticist and mechatronics mechanic, were perhaps difficult for the students to understand and for this reason, might have influenced their responses. We also recognise that the 'careers in science' could have been selected with more variety, bringing other fields of science to the fore. However, having chosen 'careers in science' from the same field of science, allows us to ascertain that variation exists in the students’ perceptions of the working life skills needed in a chemist’s and pharmacist’s careers, even though the public generally associate a chemist with a pharmacist (Schummer & Spector, 2007).

Even though the students’ perceptions of working life skills necessary to working life included the same themes as those in studies related to employers (Lim et al., 2016), workplace data (Jang, 2016), higher education students (Kallioinen, 2010), twenty-first-century skills (Binkley et al., 2012; P21, 2015; Pellegrino & Hilton, 2012) and literacy such as that offered in the Finnish National Curriculum, it is important to notice that students highlighted some of the categories differently. This would indicate the need for some new categories, ones previously lacking in earlier studies, and also suggests that although students are knowledgeable about working life skills, their knowledge is generally just stereotyped. These findings support those of earlier studies; students lack knowledge, particularly about science-related careers (Cleaves, 2005), and this affects their interest in studying and choosing such careers (Archer et al., 2014).
Conclusions

Results show that the students, having mentioned 192 different skills, already have a great deal of knowledge about working life skills; the skills mentioned are mostly in align with those demanded by employers. The skills that were omitted were mostly related to society or citizenship, organisational skills and time management skills. Also missing were the higher order thinking skills behind acquired knowledge, critical thinking and metacognition skills. Students perceived ‘careers with science’ as being more creative, innovative, collaborative and more technology and ICT oriented, while ‘careers in science’ were perceived as being more sector-specific knowledge oriented, involving more responsibility for society. These might be the reasons for students choosing ‘careers with science’ instead of ‘careers in science’, thus, it is important to introduce the demands of real-life careers and promote the opportunities for ‘careers in science’. Students need more detailed information about scientific careers; to relate the required skills and competences needed in those careers to their own skills and interests, helping them to make decisions about their future studies and careers. Our assumption is that wide-ranging information about ‘careers in science’ can be acquired if students are given the opportunity to interact with real work life problems and scientists.

Students’ perceptions of working life skills help in planning the curricula on the right lines, allowing students to make links between their own knowledge, school science, science in society and scientific careers. For further research, longitudinal intervention studies are also implied after interventions, in order to study the change and progress in students’ perceptions of working life skills. The EU project ‘Promoting Youth Scientific Career Awareness and its Attractiveness through Multi-Stakeholder Co-operation’ (MultiCO) continues this, with interventions that provide students with motivational, innovative, scientific career-related teaching. In future, research on the differences between boys’ and girls’ perceptions of working life skills and especially their choice of career, might give more information on what can be done to promote ‘careers in science’ more efficiently. This would deliver a more accurate picture about the role of science in our lives, and help to solve the challenges that our society is currently facing.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This project has received funding from the European Union’s Horizon 2020 research and innovation programme [grant agreement number 665100].

ORCID

Anssi Salonen http://orcid.org/0000-0002-7536-8286

References


STUDY II
Career-related instruction promoting students’ career awareness and interest towards science learning

Anssi Salonen, Sirpa Kärkkäinen and Tuula Keinonen

The aim of this study was to investigate how career-related instruction implemented in secondary school chemistry education concerning water issues influences students’ career awareness and their interest towards science learning. This case study is part of a larger design-based research study for the EU-MultiCO project, which focuses on promoting students’ scientific career awareness and attractiveness by introducing them to career-based scenarios at the beginning of the instruction unit. The participants in this study were three eighth-grade classes with 46 students in total, and 2 science teachers. Data consisted of observations throughout the intervention and a questionnaire which the students took afterwards. Descriptive statistics taken from the questionnaire were used together with the content analysis of open questions and observation notes. The results reveal that the students acquired knowledge about science, science-related careers and working life skills and that they enjoyed studying chemistry and engaged in learning during the intervention. The students recognized the need for professionals and their responsibilities as well as the importance of water-related issues as global and local problems, but these issues were not personally important or valuable to students. The type of career-related instruction discussed in this paper can give guidelines for how to develop teaching to promote students’ science career awareness, trigger students’ interest and engage them in science learning.

Introduction

Without promoting students’ interest and engagement towards science topics, studies and careers related to major global, national and local science topics such as problems with clean and safe water (European Environment Agency, 2012; World Health Organization, 2017), we are likely to have a lack of scientists to solve these issues (Bybee and McCrae, 2011). The problem starts with students’ career awareness, or more specifically, the unawareness of the diversity and nature of science-related careers (Maltese and Tai, 2011; Goodrum et al., 2012). Cleaves (2005) found that two factors influence students’ future science-related career choices; the first being a lack of student awareness about science occupations, scientific work and the required skills, and the second, the students’ perception of themselves which underestimates their scientific abilities. Cohen and Patterson (2012) included two more influencing factors: engagement and relevance. However, the expected difficulty of science-related studies is not a reason for students not to choose those studies and later careers (Koppenhoek et al., 2012). Furthermore, students with early awareness and personal connections to science-related careers can develop informed decisions about these careers (Osborne and Collins, 2001; Tai et al., 2006; Asplén et al., 2015). Science education should also focus on the low visibility of many science occupations in everyday life; low visibility may lead to misunderstanding and false expectations of those occupations (Schütte and Köller, 2015). Students’ perceptions of the necessary working life skills in science-related careers have indeed been found to be stereotyped (Salonen et al., 2017). Therefore, students need accurate information about science, technology, engineering and mathematics (STEM) careers and this information needs to be part of science curricula (Andersen and Ward, 2014; Holmegaard et al., 2014).

An effective method for providing career counselling is using advanced technology such as promotional videos (Harris-Bowlsbey and Sampson, 2005) and implementing career-related examples when teaching the core curriculum (Othner et al., 2013). In addition to career counselling, informing students about STEM occupations and preventing stereotypes, schools can support students’ choices for STEM careers by offering them science lessons that support understanding for all students and focus on everyday context (Koppenhoek et al., 2012; Potvin and Hasnri, 2014). Moreover, students should be actively involved in the learning process (Barron and Darling-Hammond, 2008). In the Finnish...
national core curriculum (Finnish National Board of Education [FNBE], 2014) the aims in chemistry instruction are that students will understand: the role of chemistry in everyday life, society, environment and technology; that chemistry is needed to develop new solutions; and the importance of chemistry in their future working life. Instruction should also support students’ choices on how to use their knowledge and skills appropriately. Based on these aims, chemistry education is context-based and introduces careers in which chemistry knowledge is needed. Other science subjects have similar principles (FNBE, 2014) to enhance the use of STEM careers and everyday context in promoting students’ interest towards studying science and choosing science-related careers.

Students’ possible stereotypes, lack of career awareness, self-efficacy beliefs, outcome expectations and learning experiences are the key variables influencing their career choices. However, in addition to promoting students’ career awareness, this study evaluates both students’ interest towards science learning and science-related careers, not only their career choices. Therefore, theories related to interest itself, considered together with science educational approaches, are particularly relevant to the current study.

Theoretical background
Interest can be defined as a state in which the individual is engaging or has a predisposition or intention to engage with the content (Hidi and Renninger, 2006). Interest in science has a role in the link between personal value and current science activities, and intentions for engagement in science (Ainley and Ainley, 2011a). Krapp et al. (1992) introduce two types of interest: individual interest and situational interest. Individual interest is a deeper interest developed over time or sometimes referred to as a characteristic of a person, including a person’s knowledge and values. Situational interest is something which individuals share in the moment within their environment. It usually only has a short-term effect on knowledge, feelings and values (Schraw and Lehman, 2001).

The Person-Object approach to Interest (POI) (Schiefele et al., 1983; Krapp, 1999) postulates that interest is a relational concept between an individual and the aspects of the environment providing objects of interest. Interest represents this interaction between a person and an object (Krapp, 2002). Such objects can be concrete things, topics, activities, subject-matters or ideas. While in science education the situation and topic are usually related to school science subjects, it seems that students’ interest might be something more detailed (Ainley and Ainley, 2010b). Different types of activity engage interactions between a person and objects: hands-on engagement, cognitive work and having ideas without conscious control (Krapp et al., 1992). Under certain conditions, repeated engagement may stabilize the disposition to re-engage with some of the objects, maintain situational interest and further develop individual interest (Hidi and Renninger, 2006).

Interest differs from other motivational concepts by its content-specificity. Moreover, specific features of interest include cognitive aspects, emotional or feeling characterizations, value components and the intrinsic quality of activities (Krapp, 2002). Krapp introduces two major cognitive aspects. First, developed interest always differs from the earlier stages, especially with the amount of knowledge an individual stores. Secondly, a person needs metacognitive knowledge about the missing knowledge and skills. Moreover, an interested person is eager to learn such new knowledge and skills, building on the knowledge already acquired, being independent and being alert about the problems and topics (Levitt, 2001). Furthermore, moderate prior knowledge, the potential to learn more and gaining new information combined seem to increase interest (Kintsch, 1980; Tobias, 1994; Schraw and Lehman, 2001). In the case of careers, students need more detailed information about science-related careers to relate their prior knowledge, skills and interests (Salonen et al., 2017). However, Ainley and Ainley (2011a) found that the level of knowledge that students have or acquire does not particularly affect their enjoyment of science.

Enjoyment and other emotional and feeling characterizations, even negative ones, can have a role in interest development in science learning (Ainley et al., 2005). In addition, students experiencing enjoyment with the science topic and situation are more likely to engage with the topic and continue to do so (Ainley and Ainley, 2011b). Nevertheless, some students feel that learning chemistry is irrelevant for their everyday life outside of school, their future role in society (Childs et al., 2015) and the environment (Hutchinson, 2000). Cigdemoglu and Geban (2015) found that one way to close this gap is to design chemistry education to include real-world contextual issues involving science and technology discussions with students. Education for Sustainable Development (ESD) and its implications have also been found to increase students’ perceived relevance with chemistry and the environment (Burmeister et al., 2012).

In POI, the value component refers to how the person’s goals and intentions relate with attitudes, expectations and values (Krapp, 2002). Students will study science subjects if they are needed for their career or future study goals but the importance of science for their everyday life may not be as important (Palmer et al., 2017). In addition, individual interest has major influence over students’ career choices (Aspden et al., 2015). However, students who think that science is not for them still acknowledge the necessity of others choosing those studies and careers (Goodrum et al., 2012). Moreover, information and advice about science-related career options and educational requirements increase the utility value of school science (Andersen and Ward, 2014). Students working as citizen scientists can see that science research and society can benefit from their work and contribution, enhancing the perception of valuing scientific work and engaging learners (Dickinson et al., 2012). Students should be engaged with science-related issues that are likely to be interesting and concerning to them (Jenkins, 1999). In addition, citizen-science instruction in education should be framed in such a way that students are aware of the scientific processes that they are involved in (Brossard et al., 2005).

The intrinsic quality of the activities is the most obvious feature of interest and from the POI perspective, interest-based actions have the quality of intrinsic motivation (Krapp, 2002). There is no difference between what the individual likes and has to do. However, the content and the object of the activity...
need to be taken into account when exploring interest instead of motivation (Krapp, 2002). To most students and their teachers, chemistry means activities such as inquiries and laboratory tests (Borrows, 2004). These activities are also perceived as an interesting and motivating part of chemistry learning. The work of Hofstein (2004) is a reminder that appropriate laboratory activities are effective in promoting cognitive, metacognitive and practical skills, and attitude and interest towards chemistry. However, this perception of chemistry being remote needs to be changed to show that chemistry is all around us instead. Further, Braund and Reiss (2006) propose that laboratory-based school science teaching needs to be complemented with science activities taking place outside of school.

What is found, considering these criteria, is that students engaging with different interest features including cognitive, emotional, value and intrinsic quality features in science education can perceive the importance of the content, enhancing engagement and interest with the topic and activities, and further science-related studies and careers.

The research question

Through career-related instruction and career-based scenarios, this study seeks to understand the relationships between the presentation of science-related careers to students, their interest in science and their engagement and enjoyment in science learning. Therefore, this study examines how career-related instruction can affect students’ career awareness and their interest towards science topics and science learning.

Method

The context of this case study is the EU project ‘Promoting Youth Scientific Career Awareness and its Attractiveness through Multi-stakeholder Co-operation’ (MultiCO). The MultiCO project aims to promote students’ awareness and interest in science studies and career paths. The overall methodology of the MultiCO project follows the design-based research (DBR) approach (Wang and Hannafin, 2005). This study uses mixed methods, quantitative and qualitative, providing deeper information and understanding related to the impact of career-related instruction on the students’ interest towards science studies and science-related careers in the intervention’s context. It is not possible and not the intention to generalise the results of this case study (Cohen et al., 2007).

Participants

The participants in this study were three 8th grade science groups, a total of 46 students, aged 14–15 years and their two female science teachers from a secondary school in Eastern Finland. The students had already participated in an intervention with career-related instruction. The teachers are experienced in implementing scenario-based instruction.

Intervention

The intervention (Table 1) consisted of seven lessons and three phases: a career-based scenario, an inquiry and a discussion panel. Based on a theoretical framework and the requirements of the school’s curriculum, the career-based scenario was planned collaboratively with teachers, researchers and other stakeholders. Teachers planned the inquiry and consolidation phases to link the intervention with curriculum topics.

Most of the career information was provided during the career-based scenario, particularly during lesson 2 with the professional, and later in the discussion panel. The first part of the scenario stage included information about the lake and the problem. In addition, the students and teachers briefly discussed what had already been done to the lake and who the responsible professionals are. A female environmental health officer was asked to show that chemistry is all around us instead. Further, this perception of chemistry being remote needs to be changed to show that chemistry is all around us instead. Further, Braund and Reiss (2006) propose that laboratory-based school science teaching needs to be complemented with science activities taking place outside of school.

Table 1  Intervention description

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Content and aims of lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson 1 (45 min)</td>
<td>Scenario stage in the science classroom: the students watched a film about Lake Mertajärvi, which is located near the school. A slideshow presentation continued with further information about the lake. The presentation ended with research questions:</td>
</tr>
<tr>
<td>Lesson 2 (90 min)</td>
<td>Scenario stage at Lake Mertajärvi: the students observed the surroundings of Lake Mertajärvi. The environmental health officer introduced herself, her career path and current work. She also took samples together with the students.</td>
</tr>
<tr>
<td>Lessons 3-5 (0 × 45 min)</td>
<td>Inquiry stage in the science classroom: the students examined their water samples with the following inquiries with step-by-step instructions available:</td>
</tr>
<tr>
<td>Lesson 6 (45 min)</td>
<td>Discussion panel: the students discussed the results of their inquiries. The teachers picked one student from each class as a chairman of the panel to lead the discussion of the following questions:</td>
</tr>
<tr>
<td>Lesson 7 (45 min)</td>
<td>Finish language class: the students wrote an essay about the condition of Lake Mertajärvi and what can, and needs to, be done to it. The students used their gathered results and ideas from the discussion panel to validate their arguments.</td>
</tr>
</tbody>
</table>
to participate in the career-based scenario to promote women in science-related careers. The inquiry worksheets did not include any career information. However, the teachers did remind the students during the inquiry stage about the earlier scenario stage including the career and introduced working life skills.

Data collection

Data was collected during and after the intervention (Table 2). During the intervention, the first author observed the students' interactions with the career-based scenario, educational material, other students, teachers and other adults. Observations focused on whole classroom, groups of students and individual levels. Researchers used observation sheets with foregoing variables listed to help with gathering the data. The intervention was also video recorded with one camera. The observations acted as the primary data. Video recordings were not analysed and they were used only as optional data to clarify statements and actions e.g. the teachers' choices of instruction. Notes were taken of discussions between researchers and teachers during the intervention.

After the intervention, the students answered an intervention evaluation questionnaire including 21 Likert items: 19 items were asked on a 4-point scale, but questions 22 and 23 were on a 3-point scale offering the students a neutral choice. These two questions had a following open-ended question asking about their reasoning. In addition, two open questions were also included: "20. What was best in the unit?" and "21. What was worst in the unit?". We modified a scenario evaluation questionnaire (Kotkas et al., 2017) to study how the following factors (and corresponding items in the questionnaire) triggered students' interest during the intervention.

- Knowledge (1–3, 23)
- Module attributes, enjoyment and feelings (12–15, 20–21)
- Vocational value (6, 8–10, 18)
- Personal and social value (4, 5, 7, 11)
- Career awareness (16, 17, 19)
- Interest in topic (22)

Data analysis

Observation data was analysed using content analysis (cf. Elo and Kyngäs, 2008). The analysis included two main phases: the preparation phase and the organizing phase. The preparation phase included transcribing the data and reading it through to make sense of the whole data. In the organization phase, the categories were freely generated and grouped. After using this inductive approach, a deductive approach with an unconstrained analysis matrix based on the interest criteria of Krapp (2002) was used to rearrange the categories. Descriptive statistics from the questionnaire are presented in the results. No statistically significant differences were found between girls and boys using a chi-square test with 2 or 3 degrees of freedom according to the item and $p < 0.05$. Collapsing the categories for items 1–19 did not increase the significance.

Validity, reliability and ethical considerations

Each data source has strengths and weaknesses. Therefore, in this study observations and notes from teacher discussions complemented the questionnaire data. Observation data reliability was enhanced with analysis triangulation (Patton, 1999); two researchers analysed the data separately, ending up with similar categorization and analysis of the data. Combining different instruments and data collection methods also ensures method triangulation (Patton, 1999). Greene (2015) noted that a combination of methods has a clear advantage over the use of a single method studying student engagement. Schiefele (1999) found that questionnaires usually measure interest that is more personal as the situation is over and it is challenging to remember the feelings an individual had, ending with answers mainly about their individual interest. Even though observations eliminate the problem of retrospection, there is the possibility of observer's bias affecting the results (Minnen et al., 2010).

The questionnaire items were translated into Finnish so the students could answer them in their native language. Open-ended question answers were then translated into English and the original questionnaire items in English are used in this study. Translation in both ways was done with care not to lose the meaning of the sentences. The teachers were experienced and the way of teaching was familiar to them. The researchers also worked in close, working cooperation with the teachers. The students were familiar with the researchers and the style of instruction, making it possible for them to be relaxed and participate in a normal way. The number of participants in this study was rather small. Therefore, generalization of the results is difficult or impossible. However, three groups and 46 students in a case study and in the context of the research problem is adequate to draw conclusions about the influence of career-related instruction.

The autonomy of the participant was respected and participation was voluntary, based on consent given by the students themselves.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Data collection</th>
<th>Data analysis</th>
<th>Aim of the data</th>
</tr>
</thead>
<tbody>
<tr>
<td>During intervention</td>
<td>Observations: whole class, groups of students, individual students, teachers</td>
<td>Content analysis, quantitative analysis</td>
<td>Students' interactions with the material, teachers and other adults; students' engagement and situational interest in science learning; students' awareness and interest in introduced science topics; working life skills and careers</td>
</tr>
<tr>
<td></td>
<td>Notes: discussions between researchers and teachers</td>
<td></td>
<td>Teachers' perceptions of using career-based scenarios; teachers' choices on carrying out career-related instruction</td>
</tr>
<tr>
<td></td>
<td>Questionnaire: students</td>
<td>Content analysis, quantitative analysis</td>
<td>Students' interest, motivation, relevance and attitudes towards learning science; students' awareness and interest in introduced science topics; working life skills and careers</td>
</tr>
<tr>
<td>After intervention</td>
<td></td>
<td>Quantitative analysis, content analysis</td>
<td></td>
</tr>
</tbody>
</table>

This journal is © The Royal Society of Chemistry 2018

Table 3  Categorization of observations

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students' working methods and skills</td>
<td>60</td>
</tr>
<tr>
<td>Reasoning and argumentation</td>
<td>21</td>
</tr>
<tr>
<td>Technology and instruments</td>
<td>13</td>
</tr>
<tr>
<td>Precision and caution</td>
<td>12</td>
</tr>
<tr>
<td>Instructions and time management</td>
<td>8</td>
</tr>
<tr>
<td>Notes and observations</td>
<td>6</td>
</tr>
<tr>
<td>Interaction</td>
<td>49</td>
</tr>
<tr>
<td>Collaboration and teamwork</td>
<td>18</td>
</tr>
<tr>
<td>Teacher-student</td>
<td>15</td>
</tr>
<tr>
<td>Student-student</td>
<td>11</td>
</tr>
<tr>
<td>Leading and guiding</td>
<td>5</td>
</tr>
<tr>
<td>Working life skills, careers and society</td>
<td>48</td>
</tr>
<tr>
<td>Working life skills</td>
<td>22</td>
</tr>
<tr>
<td>Careers</td>
<td>19</td>
</tr>
<tr>
<td>Society and public participation</td>
<td>7</td>
</tr>
<tr>
<td>Emotions, feelings and experiences</td>
<td>41</td>
</tr>
<tr>
<td>Frustration</td>
<td>16</td>
</tr>
<tr>
<td>Positive emotions</td>
<td>12</td>
</tr>
<tr>
<td>Negative emotions</td>
<td>8</td>
</tr>
<tr>
<td>Own experiences and empathy</td>
<td>5</td>
</tr>
<tr>
<td>Interest and engagement</td>
<td>32</td>
</tr>
<tr>
<td>Interest during inquiries and discussion panel</td>
<td>17</td>
</tr>
<tr>
<td>Interest during scenario</td>
<td>15</td>
</tr>
<tr>
<td>Engagement</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>243</td>
</tr>
</tbody>
</table>

Table 4  The results of the instruction unit evaluation

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Item (4-point Likert scale)</th>
<th>M</th>
<th>SD</th>
<th>% Agree (N)</th>
<th>% Disagree (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I gained new knowledge about the topic.</td>
<td>3.03</td>
<td>0.49</td>
<td>95 (37)</td>
<td>5 (2)</td>
</tr>
<tr>
<td>2</td>
<td>The knowledge I gained from the unit may be useful in the future.</td>
<td>2.54</td>
<td>0.72</td>
<td>56 (22)</td>
<td>44 (17)</td>
</tr>
<tr>
<td>3</td>
<td>I can use the knowledge acquired to solve problems in practice.</td>
<td>2.49</td>
<td>0.60</td>
<td>54 (21)</td>
<td>46 (18)</td>
</tr>
<tr>
<td>4</td>
<td>The topic is important for me.</td>
<td>2.13</td>
<td>0.62</td>
<td>26 (10)</td>
<td>74 (28)</td>
</tr>
<tr>
<td>5</td>
<td>This unit enables me to understand local entrepreneurs and their operations.</td>
<td>2.59</td>
<td>0.50</td>
<td>59 (23)</td>
<td>41 (16)</td>
</tr>
<tr>
<td>6</td>
<td>The topic raises my interest in studying science subjects (mathematics, physics, chemistry, biology and geography).</td>
<td>2.23</td>
<td>0.78</td>
<td>28 (11)</td>
<td>72 (28)</td>
</tr>
<tr>
<td>7</td>
<td>The topic is important for the world.</td>
<td>2.62</td>
<td>0.85</td>
<td>64 (25)</td>
<td>36 (14)</td>
</tr>
<tr>
<td>8</td>
<td>My future career may be connected with the topic.</td>
<td>1.85</td>
<td>0.63</td>
<td>13 (5)</td>
<td>87 (34)</td>
</tr>
<tr>
<td>9</td>
<td>I predict I will need to perform science-related skills learned in the unit in my future career.</td>
<td>2.15</td>
<td>0.63</td>
<td>28 (11)</td>
<td>72 (28)</td>
</tr>
<tr>
<td>10</td>
<td>I predict I will need to perform science-related skills learned in the unit in my future career.</td>
<td>2.15</td>
<td>0.63</td>
<td>28 (11)</td>
<td>72 (28)</td>
</tr>
<tr>
<td>11</td>
<td>This unit described science-related problems significant to society.</td>
<td>2.74</td>
<td>0.79</td>
<td>69 (27)</td>
<td>31 (12)</td>
</tr>
<tr>
<td>12</td>
<td>It was easy for me to relate with the situation (scenario) described in the beginning of the unit.</td>
<td>2.49</td>
<td>0.56</td>
<td>51 (20)</td>
<td>49 (19)</td>
</tr>
<tr>
<td>13</td>
<td>During the unit it was easy to study.</td>
<td>2.87</td>
<td>0.57</td>
<td>87 (34)</td>
<td>13 (5)</td>
</tr>
<tr>
<td>14</td>
<td>Working during the unit was pleasant.</td>
<td>2.74</td>
<td>0.55</td>
<td>74 (29)</td>
<td>26 (10)</td>
</tr>
<tr>
<td>15</td>
<td>I participated actively during the work.</td>
<td>2.85</td>
<td>0.54</td>
<td>87 (34)</td>
<td>13 (5)</td>
</tr>
<tr>
<td>16</td>
<td>I gained knowledge about careers new to me.</td>
<td>2.55</td>
<td>0.76</td>
<td>63 (23)</td>
<td>37 (15)</td>
</tr>
<tr>
<td>17</td>
<td>This unit helps me to understand the responsibility of the described careers.</td>
<td>2.67</td>
<td>0.66</td>
<td>67 (26)</td>
<td>33 (13)</td>
</tr>
<tr>
<td>18</td>
<td>I became interested in the described careers.</td>
<td>1.87</td>
<td>0.63</td>
<td>13 (3)</td>
<td>87 (20)</td>
</tr>
<tr>
<td>19</td>
<td>This unit helps me to understand what skills are needed in the described careers.</td>
<td>2.52</td>
<td>0.59</td>
<td>57 (13)</td>
<td>43 (15)</td>
</tr>
</tbody>
</table>

Results

The observations were firstly grouped into 19 categories and then into 5 main categories: students’ working methods and skills; interaction; working life skills, careers and society; emotions, feelings and experiences and interest and engagement (Table 3).

When comparing individual questionnaire items between girls and boys, girls perceived slightly more that their future career connected with the topic than boys ($\chi^2 = 5.460; df = 2; p = 0.065$). In all of the other items the differences between genders were far from significant with $p$-values ranging from item 13 ($\chi^2 = 0.257; df = 3; p = 0.970$) to item 16 ($\chi^2 = 0.563; df = 3; p = 0.965$). The results of the intervention evaluation questionnaire are presented in Table 4. Furthermore, we present these findings from the questionnaire with the support of observations.

Interest: enjoyment and engagement

The majority of the students perceived that they acquired new knowledge about the intervention’s science topic ($M = 3.03; SD = 0.49$) and considered the gained knowledge more or less valuable for them and useful for future practical problem-solving. However, the topic hardly raised the students’ interest to study science subjects. Discussions between teachers and researchers revealed that during the intervention teachers realized that some of the inquiries and assignments were too complex for the majority of the students to understand and therefore keep up with the phases of the intervention.

Table 4  The results of the instruction unit evaluation

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Item (3-point Likert scale)</th>
<th>M</th>
<th>SD</th>
<th>% Agree (N)</th>
<th>% Neutral (N)</th>
<th>% Disagree (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>I find the topic of the unit interesting.</td>
<td>1.86</td>
<td>0.67</td>
<td>16 (6)</td>
<td>54 (20)</td>
<td>30 (11)</td>
</tr>
<tr>
<td>23</td>
<td>I want to learn more about the topic.</td>
<td>1.70</td>
<td>0.66</td>
<td>11 (4)</td>
<td>48 (18)</td>
<td>41 (15)</td>
</tr>
</tbody>
</table>
The students showed positive and negative emotions during the intervention. Positive emotions were mainly using humour and laughing during the lessons, for example “Get those mega gloves”, “This is so precious water” and “Of course I could drink this water”. Negative emotions were associated with the condition of the lake, for example “Ugh! It smells like dead in here”. The students, especially girls, didn’t show many feelings or express their own experiences throughout the intervention towards the science topics or career introduced. However, they showed some empathy towards the condition of the lake, with phrases such as “Fortunately Lake Saimaa is not in that condition”.

The students perceived that the working and learning methods were pleasant ($M = 2.74$; $SD = 0.53$) and that studying was easy ($M = 3.87$; $SD = 0.57$) during the intervention. In addition, the majority of the students were actively participating. The observations validate the students’ enjoyment and engagement. The students were mainly positively interested ($24/32$ of observations related to interest) in the scenario and inquiry stages. In the scenario stage, students showed interest in observing nature outside of the classroom: “Are we going out already?”. During the inquiry stage, students were interested in new equipment and surprising reactions. The students showed indifference or frustration mainly in the inquiry stage, and mostly towards the use of computers and electronic learning material and because of the workload. Only a few of the students were actively participating during the scenario stage in class but most of the students worked actively during the inquiries and perceived the free working style as easy and enjoyable.

The students’ reasons for their neutral or slightly negative interest about the topic ($M = 1.86$; $SD = 0.67$) and future interest to learn more about the topic ($M = 1.70$; $SD = 0.66$) had some variation. Positive reasoning about the topic included: “It was nice to learn something new about the lake” and “Because I like to do science inquiries and calculations, even though I don’t understand all the time”. Most of the negative reasoning towards interest about the topic had no reason, but if there was a reason, it was similar to “I just did not like it”; “It just was not for me” or “Ugh, such a dirty pond”. The students’ willingness to learn more about the topic was reasoned with positive answers such as: “The topic is important” and “Some details might have been missed”. Negative reasons were linked with the perception of already learning enough or a future career aspiration, for example “I think I learned enough” or “I don’t think my future career needs skills and knowledge like this”.

Careers, skills and society

Students gained knowledge about the introduced careers and they understood the responsibilities and the working life skills required, but their interest towards these particular careers remained low. The teachers tried to involve the careers and working life skills throughout the intervention by emphasizing accuracy, safety and precision and reminding the students about the career-based scenario at the lake and about the results the chemist provided. The students usually did not react to these in any way. For example, the students posed only one question to the environmental health officer during the career-based scenario. This question was about her salary.

The students did not connect their future careers with the topic introduced in the intervention and so they did not see the practical value of the learned skills as most of them perceived that the learned skills were irrelevant to their future career ($M = 2.03$; $SD = 0.54$). Science-related skills were valued a little higher in future careers ($M = 2.15$; $SD = 0.63$). The observations and discussion panel revealed insights of how the students used their knowledge and skills during the intervention. The most noticeably used working life skills among the students were safety and accuracy: “I put this cork now and close the bottle so it falls nothing happens.”. During the inquiries, students usually wrote the results in their notebooks very precisely. Even though the students reasoned and created their own analyses in cooperation, they did not write them down. At the beginning of the discussion panel, the students were not eager to show any of their results or analyses. When they finally started to list the results, they did not add their own conclusions. Moreover, students who were a little uncertain of their own analyses started immediately to rewrite their conclusions when someone presented conclusions somehow different from their own.

The students recognized the importance and value of the scientific topic to the surrounding society and the world but not for themselves ($M = 2.13$; $SD = 0.62$). The questions in the discussion panel guided students to link their work more with society. During the discussion panel, most of the students agreed that the city has to take better care of the lake. One discussion included a comment with collective responsibility: “If the city received the lake as a donation and promised to keep it in good condition and for leisure use, then these promises have not been kept”. Students also understood that their results differed from the public perception of the lake’s condition: “Lake Mertsjärvi is chemically in better condition than people usually think”. According to the students, teachers can inform the public and policymakers about the issue, professionals in water treatment can make plans for cleaning the water and its surroundings and animal experts can take care of endangered dragonfly species living at the lake.

Discussion

This study provided students with a learning experience in which they first encountered a two-stage scenario including a science-related career and a society-related issue, inquiries and a discussion panel related to the introduced water topic. The results show that in this career-related instruction intervention the most important features of interest for students were cognitive aspects, emotional and feeling characterizations and the intrinsic quality of activities. These features triggered the transaction between the student and the objects: the topic (water), the careers (environmental health officer, chemist) and the inquiry activities (Krapp, 2002). The students acquired new knowledge about the topic, careers and working life skills. Even though the expected difficulty is not a reason to not choose to study science (Korpershoek et al., 2012), the amount of high level knowledge and skills required may have reached the limit.
The lessons when visiting the lake outside the classroom triggered the students’ interest in science learning. The inquiry part at the lake seemed to carry the students’ interest through the more demanding parts later in the classroom. Positive emotions such as humour dominated the early stages of the scenario and inquiries, especially at the lake. Negative emotions emerged when the inquiries, reasoning and reporting needed more of the students’ attention. Putting too much pressure on reporting the inquiries can kill the enjoyment and intrinsic quality of these activities. These results are worrying as the inquiries are seen as a motivating and interesting part of chemistry education and according to Ainley et al. (2005), both negative and positive emotions have an effect in the development of situational interest. However, these findings support the earlier studies (Hoefstein, 2004; Braumüld and Reiss, 2006) that concluded that inquiry-based teaching should be complemented with activities outside of the classroom, allowing students to see that chemistry is all around.

The value components in this intervention were value for the world and local society, and value for the individual. Students considered the water topic highly relevant for the surrounding society and the world, but this topic was not relevant at a personal level for the majority of the students. Even though most of the students lived near the lake, they could not yet see their role as active citizens, but could see the significance of the problems surrounding them. These results support the study by Cigdemoğlu and Geban (2013) that concluded that engaging students with real-world issues can close the gap between students and society. Moreover, the results also align with an earlier study (Childs et al., 2015) that concluded that students feel that chemistry is irrelevant for their lives and they cannot see their role in society. As clean water is actually not an everyday problem in Finland or any other European country, it might not raise students’ interest towards learning about the topic or the careers related to it (Kopershoek et al., 2012).

Career-related instruction implemented in this study introduced students to outside of school and laboratory activities, making school science (chemistry) more relevant and valuable in promoting STEM career awareness (Hoefstein, 2004; Cohen and Patterson, 2012). However, students did not relate their future career with the introduced career or scientific topic and therefore, perceived that the acquired knowledge and skills from this topic or from further science studies had little value (Palmer et al., 2017). The students might have had difficulties connecting their future careers with the science topics because they were not aware of the diversity of careers, especially in science (Maltese and Tai, 2011; Goodrum et al., 2012), and had false expectations of science-related careers (Schütte and Köller, 2013; Salonen et al., 2017). However, students see the topic’s importance for society and the world, recognizing the need for someone else working with such problems in the future (Goodrum et al., 2012).

The students had an opportunity to plan their teamwork and the teacher gave them a lot of responsibility over their learning. These teacher decisions also align with the national core curriculum of Finland and earlier studies (Barron and Darling-Hammond, 2008; FNBE, 2014), promoting cooperation and students’ active participation in learning. For some students this might have led to problems in understanding the inquiries and the whole learning process and objectives, leading to a feeling of irrelevance (Hutchinson, 2000; Childs et al., 2015).

During the inquiry phase, students had problems linking the acquired scientific knowledge and results with their own ideas and conclusions. Therefore, the teachers developed the discussion panel questions. These questions including aspects on the future and society could have guided the students’ learning and trigger their interest better than the original research questions in the scenario phase. As the discussion panel proceeded with student–student and student–teacher interactions, the students appreciated and became more aware of relations between their own and others’ arguments and were actively involved (Barron and Darling-Hammond, 2008). This might have led to students having a deeper understanding of the relationships between science, society and individuals, making chemistry and science-related careers more relevant to themselves and further triggering interest in science learning. Even though the students were interested during the intervention, it was not able to enhance students’ further interest to learn about the topic. The intervention included positive triggers to interest but it might have included too many difficult phases for the students. This could be a reason for the students enjoying and engaging during the intervention yet not re-engaging with the topic (Krapp, 2002) and promoting further interest towards science studies and careers.

Further research and implications

Further research and interventions are needed to evaluate the results for a more complete understanding of the design and use of career-related instruction as well as in relation to other key variables in career choosing such as self-efficacy, career stereotypes, and learning outcome expectations. The MultiCO-project continues to develop the design process and the evaluation of career-related scenarios and instruction in further design cycles. No significant differences between girls and boys were found in the analysis but the small number of students may have had an effect on the results and further studies with larger cohorts are necessary to test the gender difference more accurately. However, this case study might give interesting and important insights and implications in closing the gender gap in science interest. In addition, this intervention and future research can give educators help and guidelines in connecting science teaching with careers, society and working life skills.

Limitations

There is always the possibility of misunderstanding and/or loss of nuances during translation. Therefore, any translations were made with great care together with multiple researchers reviewing the translated questionnaire items and answers. The cultural
content was also challenging. Finnish students are not that interested in careers in general, much less their own career opportunities at this early age. Moreover, the students’ interest in science-related careers and science learning cannot be defined with one or two case studies. It requires persistent research with different kinds of study and consistent reporting of both successful and unsuccessful results. The small number of participants does not allow for generalization, yet the referred earlier studies validate some of the results. Unfortunately, a controlled comparative study design could not be implemented without changes in crucial factors such as the teachers and learning environment or changing the overall design of the MultiCo project. However, with multiple data sources, precise analysis of the data and careful reporting of the results, this study gives valuable information and offers other researchers and educators the possibility to make conclusions and derive their own applications.

Conclusions

Water and especially clean water in Finland is not an everyday problem for secondary school students. However, local problems with water pollution and ecosystems still occur. Water as a topic and the career-related instruction introduced in this study might give interesting guidelines for the Education for Sustainable Development (ESD) and Citizen Science approaches. This study shows that students realize the local scientific problems but their interest and engagement towards these topics vary, as they do not personally regard them as important or relevant, or link the topic with their lives.

If we can meet the students’ individual interests with introduced science topics and careers the engagement may be more obvious. Finding a topic and a career to meet every student’s interests is impossible. Career-related instruction should concentrate on emphasizing the perceived personal value and relevance of careers for the student. Thus, it can provide links between the usefulness of a topic, science studies, society and personal life.

Professional visitors in lessons are always a challenge and more attention is needed to make the cooperation more functional and promotional regarding science-related careers and working life skills. Moreover, career-related instruction could benefit from using careers, in addition to the scenario phase, throughout the teaching unit. For further opportunities to develop career-related instruction, we need to listen to students’ and teachers’ views. However, unless teachers are enthusiastic about science, they are unlikely to adopt a teaching approach such as the one presented here, as it places higher demands on them relative to regular science teaching. Therefore, introducing students to new science-related careers and working life skills enhances their career awareness and their knowledge about the variety and nature of these careers. This is required if we want students to perceive science studies and science-related careers as interesting and important for them instead of only for others.

Conflicts of interest

There are no conflicts to declare.

Acknowledgements

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement no. 665100.

References


STUDY III
Article
Teachers Co-Designing and Implementing Career-Related Instruction

Anssi Salonen *, Sirpa Kärkkäinen and Tuula Keinonen

School of Applied Educational Science and Teacher Education, University of Eastern Finland,
Joensuu P.O. Box 111, 80100 Joensuu, Finland; sirpa.a.karkkainen@uef.fi (S.K.); tuula.keinonen@uef.fi (T.K.)
* Correspondence: anssi.salonen@uef.fi

Received: 9 September 2019; Accepted: 14 October 2019; Published: 16 October 2019

Abstract: Teachers encounter the challenge of how to provide students adequate awareness of science-related careers. Therefore, innovative teaching material for promoting science-related careers needs to be designed. Educational innovations can be successful if teachers experience ownership and agency towards the designed teaching material. In this case study, a multi-professional group of two science teachers, a researcher, and a dentist co-designed instruction including a career presentation and relevant information about field-specific education and skills needed by a professional in that field. We refer to this as career-related instruction. The designed learning unit includes a scenario, inquiries and career-related activities. Teachers’ perceptions about co-designing and implementing the learning unit in science education are examined as well as students’ perceptions about the scenario. A content analysis reveals the teachers’ high ownership and agency in co-designing the instruction, which was relevant, interesting and informative for students. It was easy for teachers to implement the learning unit even though they were not involved in every phase of the design process. We conclude that by strengthening teachers’ ownership and agency through multi-professional co-designing, relevant and interesting career-related instruction can be designed and implemented.

Keywords: co-designing; instruction; learning unit; agency; ownership; careers; science education; teacher professional growth

1. Introduction

One of the challenges in school science is how to introduce science-related careers to students. Students need knowledge about different careers to be able to make informed decisions on their educational and career paths. Students are not aware of the many available career options and know few professionals working in science, technology, engineering and mathematics (STEM) fields [1,2]. At the same time, teachers struggle to introduce and use careers in science education [3] and provide students with adequate awareness of careers related to science. Even experienced teachers need to develop their pedagogy, acquire new knowledge, skills and methods, alter and adopt new teaching and novel instructional designs [4].

Imposing new educational innovations on teachers in a top-down approach is not effective [5]. Particularly in countries where teachers have high autonomy and traditionally low control from authorities [6]. Top-down approaches have been unsuccessful because the teacher’s existing personal domain is not acknowledged, and they are just set in a role to implement learning units developed by someone else [7]. Conversely to the top-down approach, the bottom-up approach increases teachers’ ownership of curriculum innovations [5]. Such innovations succeed when teachers feel that the innovation belongs to them instead of only imposing it on them [8]. Using the best aspects of both top-down and bottom-up approaches helps to introduce new philosophies, ideas and learning
units to in-service teachers and facilitates finding ways to make teachers’ existing knowledge and beliefs explicit [9]. For this, multi-professional co-designing of educational innovations offers one solution. Educational co-designing is defined as creating new or adapting existing curricular activities in collaboration with peers, experts and career professionals with up-to-date insights, and other stakeholders’ and students’ ideas [10]. Lately, a few studies have successfully brought together teachers and scientists as partners in science education [11], also with the help of technology [12]. These partnerships in educational planning help teachers to understand the relevance and usefulness of educational innovations and provide new competencies in instructional planning and implementation for teachers [13].

During the interaction in co-designing, teachers can incorporate their views about ownership and agency in relation to instruction under design and concrete teaching material [14]. Furthermore, teachers’ sense of ownership and agency is important in designing and implementing a successful educational innovation [15]. Therefore, investigating teachers’ ownership and agency helps to understand how teachers reflect on co-designing educational innovation, to students’ perceptions and how to continue designing instructional methods further.

In this case study, two teachers, a researcher, and a scientific professional co-designed a career-related learning unit and a corresponding scenario named “Coal to teeth” dealing with activated carbon and dental health and care. This study seeks to understand how a multi-professional group co-designs science teaching that is both a valuable tool for teachers, but also relevant and interesting for students. Therefore, this study aims to examine the design process of career-related instruction with the following research questions:

- What are the teachers’ perceptions about the co-designed learning unit in terms of ownership and agency?
- How do the students respond to the scenario introduced at the beginning of the learning unit?

2. Theoretical Framework

2.1. Ownership and Agency

Ownership and agency are closely related to a teacher’s identity. Ownership is a mental state of welcoming, accepting and possessing ideas such as educational innovations as part of the owner’s identity [16]. Teachers are more likely willing to invest their resources in the success of educational innovation when they feel ownership of the process and can see what is important in the innovation [17]. If teachers support the new ideas of the innovation and feel that a change is necessary, they invest their resources in designing and implementing the innovation [18]. It is important that as the implementers of educational innovation, teachers identify themselves with the innovation and communicate about it in their professional community [16]. In summary, ownership can be recognized by teachers’ needs and support for the innovation and communication about the innovation [14]. Ownership develops when teachers can co-construct knowledge and educational improvements, they have suitable support and practices to make these efforts and the value of their collective expertise and knowledge is recognized [19].

Teachers might see that educational innovations coming from the outside reduce their level of control [20] and limit their autonomy to define what and how to teach [21]. Therefore, teachers experiencing agency in their career means that they feel in control of their actions [22] and that their goals, interests and motivation guides their work-related choices [23]. To freely make these choices, teachers need a high level of autonomy [24]. Thus, both school context, co-workers and teachers themselves shape experiences of agency. When teachers are implementing new educational innovations, they accommodate the process and adjust their work according to the innovation [14]. It increases teachers’ sense of agency, when their goals match their beliefs about the benefits of the innovation. In addition, teachers linking an innovation’s successes and failures to themselves instead of pointing out external factors, shows a strong sense of agency towards the innovation [25]. The
amount of teachers’ experienced agency within their work makes a difference in their response to the innovation [18]. Therefore, to find out teachers’ experiences of agency, their own and workplace goals need to be identified and compared to inform their choices.

Teachers are interested in the salient outcomes of the instruction they implement [26]. Therefore, they are also curious about the latest educational knowledge and skills to enable students to engage in science learning. In science education, the change from teacher-and content-centered approaches to context-based approaches and collaboration with industry and community has provided promising results in promoting students’ motivation and feel of relevance for learning science and increasing uptake of science studies and careers [27,28].

2.2. Science Education Promoting Career Awareness

Science career stereotypes still exist [29,30] and school science fails to eliminate these stereotypes and emphasize women’s role in science [31]. Therefore, science education should focus on introducing, not only well-known careers such as chemists and physicians, but also less visible science occupations in everyday life [32]. Insufficient awareness of science-related careers and scientific work together with underestimating one’s own science abilities reduces students’ likelihood of pursuing science studies and careers [1]. In addition, interest, engagement and relevance influence students’ future career aspirations [33]. Several studies [34–36] conclude that school science has an impact on students’ future career choices. In addition, Dewitt and Archer [37] argue that it is not always the positive attitudes that drive students towards scientific careers. They suggest that differences in science capital helps to explain career aspirations. Hence, students need to acquire both scientific competencies but also information about careers through education.

Students feel that learning science subjects, particularly chemistry, is remote and irrelevant for their everyday life outside school and their future role in society [38]. However, students tend to think that science-related careers are important, and it is necessary that someone else choose science studies and careers even if they are not interested in that [39]. Nevertheless, without correcting students’ awareness of science careers, relevance of science and interest in studying science, the problem of students not pursuing science studies and careers will most likely remain.

The number of students making informed decisions to choose STEM studies and careers can be increased with students’ early awareness and accurate perceptions of STEM careers [40,41]. For example, socio-scientific issues bring together scientific knowledge with real-world and everyday topics in a social context [42]. Several studies, particularly outside Europe, introduce attempts to build teacher-scientist and student-scientist partnerships to improve student satisfaction, interest and engagement in science studies and careers [43–45]. In these partnerships, authentic experiences of work in science enhance students’ attitudes and understanding about careers and the latest scientific knowledge from the field [45,46]. In addition, through the partnerships, teachers can acquire new pedagogical tools, knowledge and more positive attitude towards professionals in the field. Successful partnerships usually involve either scientists visiting the classroom or students visiting authentic workplaces. However, there are critical restrictions to be considered in these partnerships: access to experts, resources, educational standards and curricula, and lack of supporting materials [47]. Therefore, not all attempts have been successful and there is a request for a new kind of instructions to be developed [43]. These school-industry/community partnerships are particularly new in Finnish science education. Career preparation has traditionally [48] been seen as the responsibility of student counselling until the curriculum reform taken into practice in 2016 when career preparation was included under every subject [49]. Therefore, teachers now struggle creating the partnerships and career-related instructions to promote students’ career awareness.

Another way to increase students’ awareness of science-related careers, relevance of science and interest in science is using real-world contextual issues involving science and technology discussions [50,51]. The scenarios are educational innovations that start science lessons and link science content with everyday life [52]. The scenarios also initiate motivational scientific thinking and
the science learning process [53]. Hence, the point of the scenario is to not only introduce scientific knowledge, but also highlight the relevance of the topic, guide towards participatory activities such as inquiries, expressing opinions, and socio-scientific decision making. In this study, the designed scenario has a career context. This kind of career-based scenario starts the learning unit and aims to present careers and scientists in multiple ways, for example, career stories, videos, interviews and visits, to increase students’ interest and motivation towards science learning. Scientific inquiries and other learning activities should take place after the scenario to frame the learning unit. Thus, students become more aware about the scientific processes that are important for working professionals [54].

3. Methods

The context of the study is the EU project MultiCO with five participating countries. The project’s aim is to promote scientific career awareness and engagement in science learning using career-based scenarios. The overall methodology of the MultiCO project follows the design-based research (DBR) approach [55] in order to develop how careers could be introduced to the students in science education. In the project, collective case studies are conducted in participating countries to develop a rich understanding but also practical implications and solutions for the problem [56]. The intention of a case study is to investigate real-life interactions of events and human behavior in unique contexts [56]. These interactions are operated by several variables and thus the use of multiple data sources is suggested for case studies even though the intention of a case study is not to provide generalized results [56]. The present case study with mixed methods, both quantitative and qualitative, provides deeper information and understanding about the co-designing process of science education teaching material in terms of teachers’ ownership and agency, and how students respond to this designed material (Figure 1).

![Figure 1. Overall methodology of the study (T = teacher data; S = student data; D = dentist data).](image-url)

The designed learning unit was implemented as an intervention (Table 1), which consisted of four lessons (total of 315 min) including a career-based scenario, inquiries and career-related activities. Teachers’ role in the first lesson was to start a discussion about the career and the assignment, which the dentist provided. The first lesson’s inquiries were instructed by the teachers but once started their role changed to guiding the students through the inquiry steps. After the inquiries the teacher reminded the students about the dentist’s assignment again and gave hints and helped them to find out how they could create their own experiments for the next time. Based on the students’ ideas of experiments, the
teachers prepared inquiry equipment and materials for the next lessons. During the lessons, teacher’s role was to provide guidance in difficult phases. Their main attention was on low achieving students. Teachers frequently reminded the students that the dentist needs the results of these inquiries and therefore the students should be precise in their experiments. It was up to teacher to decide when to show the additional interview video. With one group it was during the inquiries and with others in the end of the lesson three. In the last lesson teacher provided students with the equipment and help with the technology the students used. Moreover, their role was to lead the discussion after the dentist’s video response to the students’ results.

Table 1. Intervention description.

<table>
<thead>
<tr>
<th>Unit Phase</th>
<th>Content and Aims</th>
</tr>
</thead>
</table>
| Lesson 1 (90 min)                             | Video presenting a patient visiting a dentist and asking her about carbon toothpaste. Later in the video, the dentist gives the students the following task:  
• would you suggest the toothpaste including activated carbon to the patient who wants to get whiter teeth and compare it with other toothpastes?  
Inquiries                                                                                                                                     |
| Lesson 2 and 3 (45 and 90 min)               | • The students worked in groups of 3–4 persons and tested how activated carbon can be used to absorb colors of tea, water with colorants and a solution of copper sulphate.  
• Students plan their own experiments.  
Inquiries                                                                                                                                     |
| Lessons 2 and 3 (45 and 90 min)               | • The students tested the abrasiveness of four different toothpastes by scrubbing the toothpaste on metal sheets and silver spoons and observing the different scratches and marks the toothpaste left on the oxidized metal objects. Some toothpaste manufacturers report the relative dentin abrasion (RDA) value of abrasiveness, but it is not mandatory. Students were guided to think about why some of the manufacturers did not want to report the value.  
Inquiries                                                                                                                                     |
| Lessons 2 and 3 (45 and 90 min)               | • The students examined the toothpaste package for fluoride and other ingredients such as saccharin concentration and if the toothpaste was recommended by the dentist association or if it was clinically proven.  
• The students tested the carbon toothpaste to examine the taste, texture and abrasiveness.  
Career-related activities                                                                                                                      |
| Lesson 4 (90 min)                             | The career presentation video was presented to the students introducing a dentist’s personal career development from high school science studies to becoming a dentist, doctor and finally to her current work specializing in plastic surgery. She was asked, e.g., about her own experiences of science studies and what motivates her in her work. |
| Bridged inquiries and career-related activities | The students filled in a laboratory form of their inquiries and created a video reporting their suggestion. The video was sent by email to the dentist. Finally, a video message from the dentist was presented thanking the students for their results and providing them accurate information about teeth whitening with hydrogen peroxide. |

3.1. Participants

The participants in this study were two female science teachers and their three 8th grade science groups with a total of 41 students, aged 14–15 years. In addition, a professional female dentist and a researcher were involved in co-designing the learning unit.

3.2. Data Collection

Data was collected before, during and after the intervention (Figure 1). Before intervention, teachers and the researcher had an audio-recorded planning meeting (90 min) starting the design process of the learning unit. Furthermore, notes were taken on the discussions with the professional dentist while creating the scenario and career-related activities. During the intervention, the data from
teachers was collected with informal conversational interviews (discussions), spontaneously asking questions in a natural interaction. Usually these discussions lasted for 5–10 min.

After the scenario video, the students answered a validated scenario evaluation research instrument (SERI) \[57,58\] questionnaire, which includes three dimensions of relevance: individual, societal and vocational \[59\], interest and scenario attribute variables. The questionnaire included 28 Likert items on a 4-point scale. Four items had additional open-ended question asking students’ to give reasons for their answer: “The topic of the scenario is interesting”, “The knowledge in the scenario is useful for me”, “I liked the scenario” and “This scenario made me interested to learn more about the topic”.

After the intervention, teachers were interviewed. These retrospective interviews were semi-structured including themes: (1) Designing the instruction and links to science curriculum, (2) Career awareness and working life skills, (3) Students’ interest, engagement and relevance of science, (4) Reflecting the implementation. In contrast with the discussions, this type of interview is planned with open-ended questions and other questions might emerge from the dialogue \[ 60\]. The interviews lasted for 103 and 82 min.

3.3. Data Analysis

Before analysis, audio-record of planning meeting, notes and interviews were transcribed. All teacher data were analyzed using content analysis (cf. \[61\]). The analysis included two main parts. In the first part, we used inductive approach of content analysis to study teachers’ perceptions about the co-design process and implementation of the learning unit. Audio-record and notes were complemented with teacher interviews.

In the second part of the analysis, the interviews acted as the main data for teachers’ ownership and agency. However, the previously collected audio-record before, and notes of observations and discussions during the intervention provided more detailed and accurate information about the teachers’ ownership and agency during the emerged situations. This content analysis combined both inductive and deductive approaches. Based on reading and making sense of these transcriptions, signs of teachers’ ownership and agency was found in inductive categorization and grouping. The authors decided that since teacher’s ownership and agency are widely studied, a deductive approach was used to conceptualize the categories of teachers’ perceptions. Thus, the categories for ownership and agency are displayed in Table 2, derived from previous research. We found the following categories for ownership: supporting the design or ideas \[17\], mental/physical effort \[62\], identifying with the instruction \[16\] and need for change \[18\]. For agency we found categories: successes and failures \[25\], accommodation \[14\], autonomy \[21\] and feel of control \[20,22\].

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting the design or ideas</td>
<td>Marshall &amp; Drummond [25]</td>
</tr>
<tr>
<td>Mental/physical effort</td>
<td>Ketelaar et al. [14]</td>
</tr>
<tr>
<td>Identifying with the instruction</td>
<td>Allen &amp; Penuel [21]</td>
</tr>
<tr>
<td>Need for change</td>
<td>Konopasky &amp; Sheridan [20],</td>
</tr>
</tbody>
</table>

In addition to the content analysis of teacher data, we present the descriptive statistics from the students’ evaluation questionnaire in the results to report how the students responded to the scenario.
3.4. Validity, Reliability and Ethical Consideration

Each type of measure, for example, notes, interviews and questionnaires, have strengths and weaknesses. Combining instruments is a way to triangulate perceptions as they occur [63]. Interviews are always retrospective, and participants need to reflect on what they have experienced. Therefore, to increase the validity, discussions and notes were also taken during the co-design process and implementation. We used a validated instrument to examine students’ perceptions.

The questionnaire items were translated into Finnish so the students could answer in their native language. Multiple researchers did the translations for the questionnaire items and quotations with care to preserve the intended meaning of the sentences.

The teachers were experienced, and the way of teaching was familiar to them. Furthermore, the researcher worked in close cooperation with the teachers. The students were familiar with the presence of the researcher, so they worked normally, and their behavior was natural during the intervention. These aspects increase the reliability of collected data.

Before the project was launched, the institution’s committee on research ethics was consulted and they agreed there was no need for further ethical review of the research by the MultiCO project. In addition, the project has followed the ethical regulations and instructions on EU, national and institutional levels. The EU has received ethical statements before and during the project’s progress. Thus, the project and experiments were performed in compliance with the authors’ institute’s policy on ethics, national and international laws, and guidelines such as the Personal Data Act. Teachers participated voluntarily in the research project. The autonomy of student participants was respected: participation was voluntary, and consent was asked from students’ guardians, teachers, schools and school administrators. Privacy and data protection were taken into account; teacher identification information was removed during transcription and anonymity of the students was secured by collecting questionnaire data anonymously. Data was made available only for the use of the research group. Based on privacy principles, the school name and region are not included in the study.

4. Results

First, we present the co-design process, implementation and reflection on the career-related instruction. Second, teachers’ perceptions about their feel of ownership and experiences of agency are presented. Last, we provide the results from the students’ questionnaire answers.

4.1. Co-Design, Implementation and Reflection of the Career-Related Instruction

The teachers had already during the MultiCO project planned two career-based scenarios and corresponding learning units. Now the teachers perceived something new that had to be tested in the scenarios because they still struggled to implement an interesting and relevant way to introduce careers in science education. After the first two longer learning units, they wanted the next scenario and following inquiries to be shorter to keep the whole unit motivating to the students. The idea for the scenario and learning unit dropped into their mailbox: “We found this pharmacy advertisement with a picture of black toothpaste”. The teachers discussed this new health product, carbon toothpaste, with some of their students and had the idea to use the toothpaste in the scenario (Table 3).

The teachers had an idea of the kind of scenario they wanted implemented during their starting period of organic chemistry and carbon. They wanted the scenario to combine information about health issues, chemistry and the career of a dentist and her explanations about the health issues with teeth, e.g., cavities, fluorine and taking care of teeth. They perceived that they could easily link these issues with their earlier periods of acids and safety issues in chemistry. In the planning meeting, the teachers pointed out that they were willing to test a scenario including a career interview video, or at least a picture of a real dentist. First, they discussed that the careers would be a dentist and a pharmacist, but later they decided that only a dentist would be introduced in this scenario to keep it simple: “I think we discussed about including a chemist but we just had the chemist in previous (scenario). Then we, I think, decided
that a pharmacist and a dentist but for some reason, maybe (other teacher name) remembers why only dentist
was chosen”; “We agreed to use only one career here as it was decided that this one (learning unit) is a short and
simple one”. Teachers perceived that the dentist career could also promote women in science.

Table 3. Participation in design phases.

<table>
<thead>
<tr>
<th>Design Principles</th>
<th>Teachers</th>
<th>Researchers</th>
<th>Dentist</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Curriculum content</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Socio-scientific issue</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Career with shared context</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Career-based scenario             |          |             |         |          |
| Designing the scenario            | X        | X           | X       |          |
| Creating the scenario             | X        |             | X       |          |
| Re-designing the scenario         | X        | X           |         |          |

| Inquiries and career-related activities |          |             |         |          |
| Designing scientific inquiries     | X        | X           |         |          |
| Designing career-related activities| X        | X           | X       |          |

| Reflection and evaluation         | X        |             | X       |          |

Teachers explained how difficult it is to integrate careers in science education. Teachers did not have a professional network outside of education from which to find professionals. They also perceived that they have a lack of knowledge about what careers there might be linked to the science curriculum and inquiries. They also pointed out that even if it is included in their work through the new curriculum, there is no additional resources like time or funding: “It takes time and during normal working hours it is not possible to start this without help”. Therefore, they wanted to involve a real professional in designing the instruction to combine science knowledge from the dentist and her explanations about the chemistry issues related to dentistry.

The researcher and the dentist created the scenario based on the ideas of the teachers. The dentist was open for any ideas but wanted to keep it as professional as possible because she felt responsible for sharing information and she also worried about her professional appearance as can be seen in her following quote: “You should keep to the facts, as the profession is highly appreciated and you do not want to look like an amateur if this goes public”. The dentist understood how to raise students’ attention and what kind of information would be interesting for them. Her young patients were always interested about the equipment used in dentistry, so they were included in the video. The dentist made it really clear in the video that even the most expertized health professionals like doctors and dentists need daily help from scientists and other professionals. She also had an idea that in her interview she tells about her life outside work such as hobbies and what other books than medical books she likes to read. In addition, the dentist behaved formally when talking to the patient, but changed her behavior when she contacted the “laboratory” through video message. Creating the scenario took two hours of her time, but she experienced that it was worth it if at least a few students would learn something new about her profession and gain interest in her field. It was her idea to state that the patient had cavities so she could include more general information about dental care in the video.

At the beginning of the implementation of the learning unit, teachers presented the scenario video to the students. After that the teachers started a discussion about what the students just saw and the problems the dentist pointed out. The first inquiry introducing activated carbon followed the discussion. After the first lessons, teachers realized a problem. The scenario did not explain the connection with the toothpaste and activated carbon clear enough and they did not include it in the discussion after the video either. After the first inquiry about activated carbon, the teachers introduced
the toothpaste. They explained that it included activated carbon similar to what they had used in a previous inquiry.

The teachers supposed that discussing the toothpaste with the students before going through the first inquiries could have helped the students link the properties of activated carbon with the toothpaste and whitening of teeth. However, it was important to them to avoid interfering with the students' creativity and imagination during the inquiries:

“You are not supposed to interfere too much when the students start to think about their own inquiries and activities. If they want to test something even outside your field of expertise you should just provide them the tools for that.” T1

The teachers realized that it was good that the career of a dentist is somehow familiar to the students, but it would be good to expand the viewpoint from one career to a field of industry:

“Something familiar and safe. If the career is totally unknown to the students, they might not learn anything from it. However, it could be interesting to give something new.” T1; “A dentist just works with the patient, but what about everything in the background? There is technology beyond dentistry and several opportunities for development as well.” T2

The teachers perceived that this scenario was appropriate to start a new period in science teaching. It was motivational and something different compared to earlier lessons. The teachers were also interested in scientific topics that could be raised via the dentist’s work and how these topics could be used to collaborate with other teachers and subjects.

4.2. Teachers’ Ownership and Agency

Teachers’ perceptions about the instruction were categorized in the light of ownership and agency (Table 4). The key findings from each category are presented in the order seen in Table 4. In general, during designing, implementing and reflecting, both teachers experienced ownership and agency. They also acknowledged the benefit of co-designing science instruction as a tool for increasing their knowledge outside their area of expertise. In addition, the teachers felt this was a suitable way for them to emphasize co-teaching and co-planning of teaching.

Table 4. Categorization of teachers’ perceptions about the instruction in the light of ownership and agency.

<table>
<thead>
<tr>
<th>Categories</th>
<th>n</th>
<th>Examples of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting the design or ideas</td>
<td>12</td>
<td>“It is good that someone else gives the tasks (to students) sometimes instead of a teacher.” T1</td>
</tr>
<tr>
<td>Mental and physical effort</td>
<td>5</td>
<td>“It was easy and fun just to implement something pre-made. Made my job a little easier for once”, T2</td>
</tr>
<tr>
<td>Identifying with the instruction</td>
<td>5</td>
<td>“I have added this as one of my regularly implemented curriculum activities”, T2</td>
</tr>
<tr>
<td>Need for change</td>
<td>4</td>
<td>“Careers are hard to include in chemistry education.”, T1; “Something old with a new twist is needed”, T2</td>
</tr>
<tr>
<td>Agency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successes and failures</td>
<td>11</td>
<td>“Any mistakes in the scenario or inquiries were not anyone’s fault. It happens when you create or test something new.”, T1</td>
</tr>
</tbody>
</table>
Table 4. Cont.

<table>
<thead>
<tr>
<th>Categories</th>
<th>n</th>
<th>Examples of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accommodation</td>
<td>6</td>
<td>“It was easy to implement and to go with the flow with the students.”, T1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“I did not see any reason not to follow the collaboratively designed learning unit.”, T2</td>
</tr>
<tr>
<td>Autonomy</td>
<td>4</td>
<td>“I think after all, we implemented the learning unit just the way we designed and wanted.”, T2</td>
</tr>
<tr>
<td>Feel of control</td>
<td>3</td>
<td>“The scenario was ready so late that it made me a little unsure of what was coming and how I would manage.”, T1; “After all, I did not see any reason for not following the designed learning unit. Of course, with minor changes I made along the way”, T1</td>
</tr>
</tbody>
</table>

4.2.1. Ownership

Teachers’ ownership in relation to the instruction varied in different phases of co-designing. Teachers supported most of the ideas their colleague, the researcher or the dentist had. They perceived that the topic was relevant for the students. Teachers’ support for the learning unit became obvious when they acted along the designed learning unit activities. For example, all the videos were premade, but they introduced them to students as a real connection with the dentist to emphasize the link with schoolwork and professional work. Teachers also perceived it was easy to link the learning unit with the existing curriculum. Teachers appreciated that a professional set the problem and gave the assignment instead of a teacher.

Designing the instruction required teachers’ mental effort in planning meetings. Their mental or physical effort was not needed in creating the scenario and they perceived this as relieving. During the intervention, teachers’ mental and physical effort was obvious as they were the practical implementors of the learning unit. Teachers appreciated the effort the researcher and dentist had put toward creating the scenario, even though they had to re-design parts of the learning unit to fit in the class context.

Teachers identified with the instruction and acknowledged its benefits for them and the students. During co-design and implementation processes, they worked in close collaboration. A sign of their identification with the instruction is also that once it was implemented, the teachers discussed and shared the learning unit with their peers in school and the local area. According to the teachers, they sometimes do this, but only if they see it as valuable for others. The teachers have also implemented the learning unit several times in other classes and continued to re-design it together.

So far, the teachers had wanted to use their own scenarios instead of premade or existing ones. Now, both teachers expressed there was a need for a change as they previously unsuccessfully included careers in science education.

4.2.2. Agency

Teachers’ agency focused on their critical evaluation of the successes and failures of the learning unit. They perceived that the scenario, inquiries and career-related activities were connected to each other successfully. They were also eager to reflect on the design and practice of the instruction to make the learning unit better. For example, they realized that the first inquiries should be introduced to the students before the scenario video to create a scientific context. Later, they were more realistic about using a new approach. Overall, the teachers perceived that the students liked the learning unit and learned a lot. Thus, according to the teachers, the scenario was a success.

Teachers perceived that it was easy for them to accommodate different opinions and choices, for example, the choices made by the researcher and dentist within the scenario.

According to teachers they had full autonomy in using the scenario in the way they liked, and they had possibilities to comment on the design before implementation during various steps of the process. Occasionally teachers had a feeling that they were not in control of designing their instruction. It made them a little uncomfortable, for example, when the scenario was ready only a few days before its
implementation. However, they still trusted the researcher and dentist to develop a proper scenario for their use.

Teachers also highlighted the visual and informative appearance of the co-designed scenario and agreed to the virtual and personal contact with the dentist through video engaged students. The teachers experienced ownership and agency towards the instruction, even though they perceived that they were not in control and their physical and mental effort was not needed during some design steps. Teachers perceived that the career-related instruction was interesting for the students.

4.3. Students’ Perceptions of Relevance, Interest and Scenario Attributes

The descriptive statistics from the scenario evaluation main categories are presented in Table 5. The categories are further explained in text. Students’ answers regarding their interest and scenario attributes from open-ended questions are displayed as quotations in text.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance</td>
<td>2.33</td>
<td>0.77</td>
</tr>
<tr>
<td>Individual dimension</td>
<td>2.41</td>
<td>0.76</td>
</tr>
<tr>
<td>Societal dimension</td>
<td>2.36</td>
<td>0.71</td>
</tr>
<tr>
<td>Vocational dimension (knowledge gain)</td>
<td>2.75</td>
<td>0.62</td>
</tr>
<tr>
<td>Vocational dimension (future aspiration)</td>
<td>1.96</td>
<td>0.72</td>
</tr>
<tr>
<td>Interest</td>
<td>2.27</td>
<td>0.40</td>
</tr>
<tr>
<td>Scenario attributes</td>
<td>2.99</td>
<td>0.41</td>
</tr>
</tbody>
</table>

The students perceived the scenario individually and as socially relevant, but there was variation within the categories. Individually, the students perceived that they could link their new knowledge about the scenario topic and careers to their future needs. However, they did not find the topic personally important, but it was important for learning school subjects. Conversely, the students perceived the topic important for the whole world and the scientific problem was socially relevant. Vocational knowledge and future aspiration divide the students’ perceived relevance of the vocational dimension. According to the students, they gained new knowledge about possible careers for them. Moreover, the scenario helped them to understand the skills and responsibilities associated with the career. The students’ aspiration to pursue a similar career was low. However, their future studies might be somehow related with the topic in the scenario. Some students perceived they would not need the new knowledge related with the topic, but others thought they might need it if they would have a career in the field: “If I would become a dentist or something similar”.

Even though the students’ overall interest was not high, it was the scenario itself that aroused their interest. They had already learned a lot about the scientific topic and careers, so they were not interested in learning more about the topic of the scenario. Only a few students gave explicit reasons why: “The career is not interesting”; “I’m not so interested that I would like to know everything about the topic”. Nevertheless, students highly appreciated the scenario’s appearance. It was easy to follow and understand for the students: “It was a little boring but finely done”; “It was easy-going, and the topic was covered well”; “Easy to follow”.

5. Discussion

The teachers explained how difficult it is to integrate careers in science education [3] and needed novel educational methods to overcome this challenge. Thus, their goals and interests (cf. [23]) and their need for change [18] led them to co-designing an educational innovation. They wanted to involve the researcher and a real professional in designing the instruction combining science knowledge with the career of a dentist and her explanations about the chemistry issues with teeth. It was important for them to include this information in their local curriculum as proposed in previous research [64,65].
The teachers experienced a high sense of ownership and agency towards the instruction, even though they were not involved in all phases of the co-design process \[13,14\]. The results of teachers’ high ownership and agency aligns with the students’ perception of a successfully implemented co-designed career-related instruction \[15\].

The teachers highlighted the visual and informative appearance of the co-designed scenario and agreed that the virtual and personal contact with the dentist through video engaged students in following science inquiries. Thus, the design and other ideas of the co-designers were supported \[17\]. Retrospective interviews revealed that they have continued to use and develop the scenario further. In addition, they have shared it and discussed it with their colleagues. This is a sign of feeling ownership as Pierce et al. \[16\] argues.

When teachers are free to implement the co-designed scenario and the rest of the learning unit in their own way, it promotes their autonomy and further experiences of agency \[21\], which is particularly important when the teachers are used to high autonomy in their work \[6\]. After all, the results of the co-design process show that the teachers participated in all the phases except creating videos for the scenario and career-related activities. However, the teachers need the freedom to change everything in the scenario and learning unit and in this case, they used this possibility a few times when they felt it was necessary. The teachers perceived that it was easy to implement the scenario and it was successful \[25\]. Nevertheless, in such a co-design process teacher can lose some aspects, for example, feelings of control \[20\] and autonomy \[21\], but gain others such as a professional’s viewpoint and new knowledge. In the end, the teachers appreciated that the learning unit was relevant and interesting for the students, but they were also interested in the students’ perceptions.

The results reveal that the students found that the scenario starting the instruction was relevant for them personally and for society. Their perceived high vocational relevance, particularly with vocational knowledge, suggests that it is possible for this kind of instruction to correct possibly existing career stereotypes \[29,30\]. According to the teachers and students, it seems that the problem assigned to the students personally by the dentist had an impact on students’ interest in the following learning activities. Earlier studies confirm that these kinds of real-world connections \[50,51\] and student-scientist partnership \[44,46\] are relevant and increase students’ interest in science. The results and previous research reveal it is not always easy or possible to create and implement this kind of authentic environment \[13\]. However, the artificially created interaction between students and professional in the designed instruction helps with the problem of resources and access to experts \[47\].

Even though the career of a dentist probably was familiar to the students before, the students perceived that they learned more about the skills and responsibilities needed in the career. Thus, career-related instruction gives students new knowledge, not only about scientific topics, but also about careers and needed working life skills and responsibilities in a career. All these raise students’ career awareness and gives them accurate perceptions of STEM careers, which is assumed to increase the number of students choosing STEM studies and careers \[40\]. Considering that generally Finnish secondary school students are not that interested in science studies or science-related careers \[66\], their future career aspirations were moderate. The students’ interest in the scenario was high and it might raise their interest towards learning science.

As said, teachers, but also students, appreciated the scenario’s attributes and appearance. Something new and different always arouses interest. Videos, connection with a professional, freedom to choose and create inquiries, and using creativity in reporting results makes science learning relevant and interesting for the students and involves them in scientific processes and decision making \[53,54\]. Without the career introduction and interaction with the professional, students might learn the same scientific knowledge and skills but lose connections and understanding how and why their knowledge and skills are relevant outside the school context.

This type of career-related instruction helps the students meet professionals working in STEM fields and gives them the opportunity to learn about new and unknown careers or something new about a familiar career \[2\]. This possibly increases the number of students choosing science
careers [67], or at least promotes the overall appreciation of science-related careers in society [39]. Even though the connection with the real professional was through videos and not authentic, it made students feel their contribution was valued. Career-related activities also help teachers plan learning units with connections to everyday life and emphasize the link between science and society [31]. The career-related instruction studied in this paper shows a good example of the usefulness of multi-stakeholder cooperation in designing science education.

5.1. Further Research and Implications

Co-designing career-related instruction needs more studies, particularly bringing together familiar (peers and colleagues) and unfamiliar (science professionals, researchers, policy makers and educational designers) co-designers with the teachers. More research is also needed focusing on teachers' positioning towards different career-related instructions and design processes to find out if there are variables other than ownership and agency that make the implementation successful. Studies on career-related instruction itself have already been reported but more research is needed to refine the idea of combining scenarios, inquiries and career-related activities.

This case study and future research can give researchers and educators guidelines for connecting science teaching with careers. Moreover, it exemplifies good conditions for co-designing science instruction. The findings will not only have practical implications for introducing the design of a career-related scenario and learning unit, but also practical implications for teachers to understand how to confront and implement innovation in education.

Teachers struggle to find school-industry/community partnerships. Multi-stakeholder cooperation provides them support from researchers, scientific professionals and peers. Once partnerships are established it is easier for the teachers to continue developing more advanced instructions with their partners. However, the teachers need help, time and resources to initiate finding these partners. Projects and studies considering this issue are welcome in the field of science education and in-service teacher training.

5.2. Limitations

Although this study provides useful information about co-designing career-related instruction, it has some limitations. Nuances can be lost or misunderstanding the information participants provide can occur during transcription and translation processes. In this study, questionnaire items were translated and checked by multiple researchers. One researcher interviewed the teachers, transcribed and translated quotations to be sure no information was lost. The data was collected from two teachers and their three groups in one school and it is likely that different co-design processes could have emerged among teachers and students with different backgrounds. However, this co-design process and the career-related instruction can be addressed to different contexts without changing it.

The number of participants in this study was small and therefore it is not intended as a case study to generalize the results [56]. There could be more complicated reasons for students’ future science-related career aspirations. However, two teachers, three groups and 41 students in a case study, and in the context of the research problem, is adequate to draw conclusions about the co-design process and influence of career-related instruction in students' perceptions of relevance and interest of the science-related career and topics. In addition, multiple data sources and precise analysis and reporting gives other researchers and educators valuable information. Besides, educational intervention can be novel, useful and relevant without fully understanding the underlying affecting mechanisms [68].

6. Conclusions

We conclude that combining top-down and bottom-up approaches in the instructional co-design processes results in successful and satisfactory designs for teachers and students. Teacher’s ownership and agency are important in co-designing and implementing innovative instructions that promotes students’ interest towards science learning. Co-designing career-related science instruction succeeds
when teachers support the ideas of innovative instruction, critically reflect on successes and failures, feel that the change is necessary, and have control over implementation. Otherwise, it is unlikely that they would adopt such a working method. The critical components of career-related instruction are the lack of resources such as time, materials and peer support, and access to experts. At first, the co-design process requires more effort than planning regular science teaching. However, if co-designing is done effectively with different roles for different designers, it is possible that everyone will benefit from it. Moreover, it is not as time consuming as one might think and well-designed instructions are useful year after year. Once teachers start creating the school-industry/community partnerships, their professional network grows and it becomes much easier to access new experts from different fields. For further opportunities to co-design career-related instruction, we need to find out what the scientists’ and teachers’ professional goals, interests and motivators are so that they can participate as co-designers.

In career-related instruction, students recognize scientific problems and have the possibility to become interested in the covered science and health topics. Students gain a lot of new knowledge about careers which corrects possibly existing stereotypes, yet their future career aspirations may remain low in individual cases. Therefore, career-related instruction should concentrate on emphasizing the perceived individual and societal relevance of the topic and introduced careers for the student. Thus, the instruction can have longer lasting and more meaningful effects for the students’ future, enabling students to see the connections between careers, topics, science studies, and their personal and professional aspirations later in life. Co-designed scenarios might attract students and give them possibilities to acquire this new knowledge. Achieving the goal of supporting students’ future career aspirations in science is more challenging through short interventions. However, using career-related instruction in the long term increases students’ realistic science-related career awareness and furthers their aspirations to pursue those fields. Furthermore, teachers experiencing ownership and agency towards co-designing such career-related instruction will enable more careers to be introduced in science education in the future.


Funding: This project has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under grant agreement No 665100.

Conflicts of Interest: The authors declare no conflict of interest.

References


24. Edwards, A. Recognising and realising teachers’ professional agency. *Teach. Teach.* 2015, 21, 779-784. [CrossRef]


32. Schutte, K.; Köller, O. Discover, understand, implement, and transfer: Effectiveness of an intervention programme to motivate students for science. *Int. J. Sci. Educ.* 2015, 37, 2306-2325. [CrossRef]


PUBLICATIONS OF THE UNIVERSITY OF EASTERN FINLAND
DISSERTATIONS IN EDUCATION, HUMANITIES, AND THEOLOGY


133. Niko Flink. Early maladaptive schemas, chronic depression and suicidal ideation. The role of maladaptive cognitive structures among patients with depression. 2018.
146. Li Wang. The learning experiences of Chinese postgraduate students at the University of Eastern Finland. 2019.
150. Minna Mäkinen. “Se ei ragee ja popittaa meidän kaa”: matkalla monipuoliseksi musiikkikasvatustajaksi. 2020
ANSSI SALONEN

Scientific careers attract few students. This dissertation presents a design-based research to develop career-related science education. Students' career awareness and co-designing science education with various stakeholders are investigated. Research contribution delivers a model of career-related instruction promoting career awareness and the attractiveness of science. This instructional framework can be implemented in science education but also in different subjects and fields of education.