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Effect of Embedded Careers Education in Science Lessons on Students' Interest, Awareness, and Aspirations

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Abstract
In the last decades, secondary school students have indicated a low interest in science and a lack of awareness of authentic science careers that may impede their aspiration to work in science-related fields in future. To raise students' aspirations, several studies used context-based approaches, but few integrated career aspects into the school curricula. Accordingly, this study aimed to promote lower secondary school students' interest in and awareness of science careers by introducing science career-related scenarios reflected in a real-world context as embedded careers education in science lessons. In this study, we explored the effect of the interventions on students' interest, awareness, and aspirations towards science careers using Estonian, Finnish, and German datasets. According to the results, the students participating in the project indicated a higher interest in science, aspiration towards science careers, and awareness of future careers than those who did not experience the embedded science career interventions. Also, the results showed that when students got more information about science careers at school, their interest in science was more easily transferred to their aspirations in science studies and careers. Thus, this result emphasizes the importance of fostering awareness of science careers at lower secondary schools in order to inspire young learners to engage in science studies and works in future.

Keywords STEM aspiration · Career awareness · Embedded career education

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Introduction

Inspiring young learners to engage in science is a long-standing goal of science education because of a decline in students' interest in science and science-related careers as they get older (DeWitt et al., 2014). The origin of the problem of lack of student interest or motivation, particularly in secondary science education, is seen to lie in pedagogical considerations (Potvin & Hasni, 2014). Accordingly, much research has been conducted to find factors fostering interest in science at school and found that one of the prominent promoters of science interest is making science lessons more relevant to students' real-life and society (Kang & Keinonen, 2018; Potvin & Hasni, 2014; Stuckey et al., 2013). Thus, linking science contents with society has become a global trend in science education practice and research by using the approaches such as context-based learning (CBL), socio-scientific issues (SSI), or science, technology, society, and environment (STSE) emphasizing the teaching of scientific developments in learners' social, cultural, political, and economic contexts (Kang et al., 2019; Pilot & Bulte, 2006). Interestingly, a recent PISA (Programme for International Student Assessment) study reported that 15-year-old students, especially from western countries like Australia, Canada, or the UK, indicated higher intrinsic motivation to learn science in 2015 compared to 2006 (Organisation for Economic Co-operation and Development [OECD], 2016). Thus, those efforts of researchers, policymakers, and educators to make science lessons more relevant may contribute to this positive trend of science interest in those countries.

On the other hand, however, students still lack awareness and aspiration to science careers (Archer et al., 2020). Several studies indicate that students' intention to work in science-related fields at the age of 14 or 16 was the key predictor of their actual choice to work in science (Schoon, 2001; Tai et al., 2006). However, many students lack awareness about authentic science-related careers and work (Maltese & Tai, 2011) and have misconceptions about science professions (Archer et al., 2013; Masnick et al., 2010). Especially lower secondary school students are often not made aware of career options, and few indicate knowing professionals actively working in science, technology, engineering, and mathematics (STEM) fields (Maltese & Tai, 2011). This may lead them away from science careers in future because awareness of such careers increases one's intention to work in the field (Blotnicky et al., 2018; Porfeli & Lee, 2012; Salonen et al., 2018). Therefore, embedded models of career education through science lessons at school that are respectful of and helpful to students are recommended (Archer et al., 2013; Reiss & Mujtaba, 2017).

Accordingly, this study investigated the effect of the interventions using embedded careers education in science lessons at lower secondary school on students' interest in science, and awareness of and aspiration towards science careers. In addition, this study explored the relationships between interest, awareness, and aspirations based on the previous literature reviewed. Specifically, it examined whether students' awareness of science careers bolstered the positive relationship between science interest and aspiration demonstrating the important role of career awareness in the career development process during adolescence.

Students' Interest and Aspirations Towards Science

Several social psychology and cognitive theories relate individuals' occupational choices to intrinsic factors. According to Eccles' expectancy-value theory (EEVT), for instance, one's intrinsic value on learning certain topics affects one's career choice in future (Eccles et al., 1983). Intrinsic value in EEVT is often used as a similar concept of interest or intrinsic motivation suggested by Hidi and Renninger (2006) or Ryan and Deci (2009). In educational studies, interest is often understood as a relation between a person and an object (Krapp & Prenzel, 2011) and, thus, referred to as personal-oriented, comparatively stable disposition towards a specific area or subject, like science (Hidi & Renninger, 2006). Accordingly, studies using EEVT show that students' interest in specific subjects predicts both intentions and actual decisions to persist at different activities, such as taking science courses (Wigfield et al., 2017). Similarly, the social cognitive career theory (SCCT) by Lent and his colleagues (1994) shows how interest is related to a career goal and action. The core components of the SCCT model are interest, self-concept, and career goals that are intricately linked with contextual factors, and the theory posits that one's career aspiration and actions are strongly tied to interest. In science education, for instance, students' interest in science has been revealed as a keystone to engage more students in a science career (Fouad et al., 2010; Simon & Osborne, 2010). Accordingly, much research has presented a linear positive relationship between interest in science and aspirations towards science careers (e.g., Kang & Keinonen, 2018; Kang et al., 2019, 2021; OECD, 2016). That is, the probability to pursue science-related careers increases when students are more interested in science, and vice versa. However, students' interest in science and aspirations towards science studies and careers have raised concerns in the past decades. Many studies conducted in western countries show that students lack aspiration towards science-related careers (OECD, 2016; Osborne & Dillon, 2008) and tend to have negative attitudes towards science (Potvin & Hasni, 2014). There are many complex reasons for the lack of aspiration and negative attitudes among secondary students (Sahin et al., 2018), but broadly speaking, they can be divided into three factors, which are (i) systemic factors, such as curriculum-related issues, (ii) school factors, such as guidance and quality of education, and (iii) internal factors, such as interest (Bennett et al., 2013; Kang et al., 2021). In their review article, Reinhold et al. (2018) show that most of the underlying research regarding career aspirations examines one of these factors, and many of these studies are based on the SCCT framework, which suggests that internal factors such as interest or self-efficacy are a key component of career choice (Bandura et al., 2001). The SCCT model also underlines that these internal factors are extensively affected by learning experiences, in the case of students, that are related to school curriculum or quality of school education.

Indeed, there is a large body of research that shows the effect of school factors on students' interest and aspirations (Reinhold et al., 2018). Basl (2011), for instance, explored relationships between 15-year-old students' science-related career interest and school characteristics as well as family background using PISA 2006 data of the Czech Republic, Germany, Finland, and Norway. According to the results, while the impact of family backgrounds such as parents' occupation or educational level was negligible, school factors were found to be a strong predictor of future career aspirations in all of the participating countries. Specifically, the effect of information about science-related careers offered by school on future career aspirations was significantly higher than students' science achievement and gender. Therefore, he concluded that "the interest in future careers is significantly influenced by the degree to which the school prepares students for future education and careers" (Basl, 2011, p. 156). Similarly, Sasson (2021) reported that while school factors such as studying science subjects or participation in scientific research were revealed as strong predictors of students' STEM career choice, family factors indicated no relationships with their STEM aspirations. An extensive review article by Potvin and Hasni (2014) also points out that in addition to several internal factors, school interventions affect students' attitudes and interests towards science careers. As giving students the opportunity to explore and to be familiar with science-related careers, such interventions may increase their interest in science studies and careers (Bennett et al., 2013; Sasson, 2019). Accordingly, researchers argued that school-based initiatives expanding knowledge of STEM careers should be provided (Archer et al., 2013; Holmes et al., 2018).

The Important Role of Awareness in Promoting Science Aspirations

Awareness of science careers is also known to be a precursor of aspirations (Blotnicky et al., 2018). A recent longitudinal study, ASPIRES, led by Archer and her colleagues in the UK pointed out the important role of awareness in increasing science aspirations. According to their study, "low science aspirations are not due to a lack of interest in science" (Archer et al., 2020, p. 5) but are more related to science capital such as having social contacts with or "knowing someone who works in a science-related job" (Archer et al., 2013, p.5). In other words, students' interest in science may not directly translate into aspirations to become a scientist unless they have specific knowledge on science careers or personal contact with scientists. Thus, the study shows that awareness of science careers can moderate the relationship between interest and aspirations. Unfortunately, students often lack awareness of authentic science-related careers and work (Maltese & Tai, 2011; White & Harrison, 2012) since there is a shortage of opportunities to explore science careers in authentic environments (Bennett et al., 2013; White & Harrison, 2012) or a lack of social contacts with scientists (Archer et al., 2020).

Porfeli and Lee (2012) introduced a process model of vocation identity as three stages—career exploration, career commitment, and career reconsideration. Briefly, career exploration refers to students' exploration in the world of work to get a better understanding of potential career options; career commitment refers to students' career choice and their effort to attach themselves to that choice; career reconsideration refers to rethinking their career commitments and comparing other alternatives to specify or change career choices. According to their vocation identity model, students who have enough opportunities to explore careers broadly and deeply during adolescence are more likely to be committed to a career they choose and spend less time finding other options in future. Therefore, Porfeli and Lee argued that

"Adolescents who did not explore enough to make a commitment could benefit from interventions that stimulate thinking broadly about themselves and a range of suitable career choices to facilitate in-breadth career exploration and a focus on general work features that align with their strengths and weaknesses" (2012, p. 19). Therefore, in order to increase young students' awareness of science careers, it is recommended to conduct interventions from formal, non-formal, or informal science education that introduce authentic science careers at an early career development stage.

Another reason that decreases students' awareness of science careers is uncertainty as to whose responsibility it is to discuss different career opportunities with students. In some countries and schools, this may be viewed as the responsibility of guidance counselors. However, the counselors may not have a science background and may not be aware of the broad spectrum of available science-related careers (Schmidt et al., 2012). Therefore, in some countries, more responsibility is given to the subject teachers. For example, the latest Finnish curriculum reform in 2016 emphasizes the need for increasing students' career awareness, not only by study counselors, but in every school subject in collaboration with student counseling (FNAE, 2014). However, the problem with teachers having the responsibility of presenting science careers is that they often do not have (1) up-to-date knowledge, (2) first-hand experiences in science careers, and (3) enough time to offer guidance (Mansour, 2015; Watermeyer et al., 2016). Thus, in order to support teachers to integrate their responsibilities in teaching science subjects and career guidance, it is beneficial to promote embedded models of careers education in science lessons that are developed by experts in the fields of science (Archer et al., 2013; Drymiotou et al., 2021; Reiss & Mujtaba, 2017).

Research Aim and Questions

Accordingly, in order to increase students' awareness of science careers and to support teachers to introduce science careers during their school lessons, the MultiCO project had been launched in five European countries for three years (a detailed description of the project is provided in the next section). Using the data from the MultiCO project, this study explored the effects of embedded models of science careers education on students' interest, awareness, and aspirations towards science careers. In addition, as reviewed, while much research focuses on the linear relationship between interest, awareness, and aspirations, to our knowledge, no studies have been examined the moderating role of awareness between interest and aspirations. Accordingly, this study explored whether students' awareness of science careers enhanced the positive relationship between science interest and aspiration. Following the aims of this study, we addressed the research questions as below.

RQ1. Does the embedded career education in science lessons have an impact on students' interest, awareness, and aspirations of science careers? Based on the previous studies indicating that context-based science education has increased students' interest in science, it is hypothesized that the embedded career education as the context-based learning affects students' attitude positively (Pilot &

Bulte, 2006). Also, as recommended by several studies, it is expected that using embedded career education in science might increase not only their awareness of science careers but also their aspirations towards studying and working in the field of science (Archer et al., 2013; Reiss & Mujtaba, 2017).

RQ2. Does awareness of science careers moderate the relationship between interest and aspirations? As the previous studies indicated, a linear positive relationship is expected between interest and aspirations (Kang & Keinonen, 2018; Kang et al., 2019, 2021; OECD, 2016). In addition, although there were no previous studies on whether awareness moderates the relationship between interest and aspirations, it is expected that awareness indicates not only a positive relationship with aspirations but also moderates the effect of interest on aspiration in a positive way. According to Archer et al. (2020), student's interest in science is not always related to their intention to pursue science-related careers unless they have a contact with science person or aware specific science careers. Therefore, we hypothesized that awareness of science careers will enhance the relationship between interest in science and aspirations towards science careers.

Method

Research Context and Procedure

In this part, we briefly introduce the MultiCO project and scenario interventions as research contexts of this study. The MultiCO project studied the impact of the introduction of real-life related, career-focused stories, referred to as scenarios, which initiate context- and inquiry-based science studies for secondary school students (ages 13 to 15) in five European countries, Cyprus, Estonia, Finland, Germany, and the UK. The intended outcome was to foster the students' interest in science, to motivate them to extend science studies, and to orient them towards considerations of undertaking science careers. This has been undertaken through longitudinal studies involving interventions using motivational scenarios. About 25 scenarios were created in multi-stakeholder co-operation and evaluated by students (Kang et al., 2019). They included a socio-scientific issue to be resolved in a context, an introduction to careers and lead to an inquiry setting and consolidation to further promote curriculum competencies. Since the scenarios were to be integrated with the regular science lessons at school, they were developed based on four science subjects—physics, chemistry, biology, and geography. Science-related careers introduced in the scenarios were an acoustic engineer, dentist, inorganic scientist, botanists, agricultural engineer, veterinary surgeon, transport planner, district manager, and process specialist to name a few. Also, specific tasks that were related to the careers were given to the students to solve, such as building a solar panel (physics), developing soft drink (biology and chemistry), investigating crime scene (biology and chemistry), and planning city (geography) (Kang et al., 2019; Soobard et al., 2020).

Students at school were followed for two and a half years with five interventions. That is, 7th graders aged 13 started to engage in this project until they graduated the lower secondary school as 9th graders at age 15. Per country, three schools took part in the project with altogether about 500 students actively involved in the interventions as experimental groups. We also gathered data from control groups at the same schools who were taught by the teachers using the same science curriculum and normal science teaching approaches except the embedded career interventions. Since participating students were not randomly selected and assigned to experimental and control groups, the nature of the study design was quasi-experimental using the intact groups. However, no participating schools had student selection processes such as entrance examination; rather, students were designated to attend the schools near their residence; they were randomly assigned to science classes in the school regardless of their backgrounds; thus, there must be no significant differences between experimental and control groups in terms of initial science aspirations and career awareness.

The scenario interventions introduced different local or global scientific contexts with references to students' everyday lives. Depending on the situations of each country, scenarios that were relevant to their curricula and drew students' attention were selected (Kang et al., 2019). Table 1 presents a typical example of how the interventions were implemented in the MultiCO project (more scenario examples can be found on the project website, multico-project.eu). The career-related scenarios presented either an authentic or real-world based fictive concern or issue, and the professional(s) tackling these problems. The scenarios introduced one or several science-related careers, for example, through the authentic working life skills they need in their work or the steps in their careers. Scenario-based career discussions continued within or after the scientific inquiries relevant to school curricula for each country. Typically, the interventions included additional career activities within or in connection to the scenario to promote students' awareness and attractiveness of science-related careers. The interventions also involved introductions and discussions of relevant working life occupational skills, since how students perceive achievement of such skills to be important in science-related careers is more likely to lead to aspirations regarding those careers.

Data and Measurement

In the MultiCO project, students' science interest development was measured by quantitative and qualitative methods during and after each of the five interventions. Among them, we used the post-questionnaire including constructs in question such as students' study and career plans after secondary school. Specifically, we selected 16 items that reflect the four constructs measuring interest, aspiration, and career preparation and information as shown in Table 2. The five items to measure *interest* were taken or adapted from Frenzel et al. (Interest in Mathematics; 2012) and Owen et al. (STAQ, Subscale "Science is fun for me"; 2008). They reflect the three components of the interest construct, having students rate how much they like science (emotion), how relevant science is for them (value), and how much they want to learn about science topics (knowledge) (Hidi & Renninger, 2006). For the other constructs, items were used from PISA 2006 scales: To measure the students' *aspirations* to take up a science-related career, the four items were used. For the

Table 1 An example of the MultiCO scenario intervention

Lesson	Lesson content
Lesson 1 (90 min)	*Career-related scenario:* Video presenting a patient visiting a dentist. The patient asks about a new product: carbon toothpaste. In the video, the dentist sets the *concern* of the value of the toothpaste and gives the *task* to students: • Would you suggest the toothpaste including activated carbon to the patient who wants to get whiter teeth and compare it with other kinds of toothpaste? *Inquiries* • 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 solution of copper sulfate
Lesson 2 (45 min)	*Inquiries* • The students tested the abrasiveness of four kinds of toothpaste 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 RDA value of abrasiveness, but it is not mandatory. Students were guided to think about why some of the manufacturers did not report the value
Lesson 3 (90 min)	*Inquiries* • The students examined the toothpaste package for fluorine and other ingredients such as saccharin concentration and if the toothpaste was recommended by the dentist association or clinically proven • The students tested the carbon toothpaste to examine the taste, texture, and abrasiveness *Career activity* A career presentation video was shown to the students introducing the career development of the dentist presented in the first lesson, from school science studies to dentists, doctor, and finally to her current work in specializing in plastic surgery. She was asked, e.g., about her own experiences of science studies and what motivates her in her work
Lesson 4 (90 min)	*Bridged inquiries, task, and career activity* The students filled a laboratory form of their inquiries and created a consolidation video telling their suggestions for the dentist. 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 in dental care

students' *career awareness*, two factors were used: on the one hand, the students' perceptions of the usefulness of schooling as *preparation* for science-related careers, and on the other hand, the students' perceptions of being *informed* about science-related careers (see PISA 2006 Technical Report (OECD, 2009) for more information).

For the development of the instrument, all materials were circulated in the project consortium for comments and feedback. An English source version of the interest scale was then distributed to the partner countries as a basis for translation into national versions. The other items that have been selected for the study presented here could be used directly as they had already been translated during the PISA studies into the national languages involved in the project.

One semester after the last intervention of this project, experimental group students (9th grader, average age 15) were asked to fill in the questionnaire. In addition, students of the same age but who had not been involved in the project filled the same questionnaire.

Table 2 Items and constructs/factors (selected from the MultiCO post-questionnaire)

Factor	Description
Interest	How strongly do you agree?
	Doing science is one of my favorite activities
	I would like to find out much more about some of the things we deal with in our science class
	I really like science
	I enjoy science courses
	Science is very relevant to me
	4-point Likert scale: "strongly agree" – "strongly disagree"
Aspiration	How much do you agree with the statements below?
	I would like to work in a career involving natural science
	I would like to study natural science after secondary school
	I would like to spend my life doing advanced natural science
	I would like to work on natural science projects as an adult
	4-point Likert scale: "strongly agree" – "strongly disagree"
Awareness	
Preparation	How much do you agree with the statements below?
	The subjects available at my school provide students with the basic skills and knowledge for a science-related career
	The school science subjects at my school provide students with the basic skills and knowledge for many different careers
	The subjects I study provide me with the basic skills and knowledge for a science-related career
	My teachers equip me with the basic skills and knowledge I need for a science-related career
	4-point Likert scale: "strongly agree" – "strongly disagree"
Information	How informed are you?
	Science-related careers that are available in the job market
	Where to find information about science-related careers
	The steps students need to take if they want a science-related career
	4-point Likert scale: "Very well informed " – "Not well informed "

Since the aim of this study was not a comparison between countries, we checked whether all the datasets of the five countries could be used together as one cohort. However, a preliminary EFA result indicated that the data of Cyprus and the UK concerning the four constructs focused on in this study had to be excluded due to the validity issue (see Appendix). Thus, only Finnish, German, and Estonian datasets were used in the study presented here.

The questionnaire was completed by 747 students from the three countries. Of these students, 350 had taken part in the MultiCO project (= intervention group) and 397 belonged to the non-intervention group (see Table 3 for a detailed description and gender distribution).

Table 3 Sample description

	Total	Intervention group	Non-intervention group	Age (mean)
Finland	375 (female, 49%)	116	259	15
Estonia	116 (female, 44%)	93	23	16
Germany	256 (female, 60%)	141	115	15

Analysis

As mentioned, since this comparison study aimed to compare not between different countries but between intervention and control groups of the MultiCO project, we first tested whether all participating countries' data indicated similar structures for the core constructs in order to merge the datasets together as one cohort. In order to test the construct validity of the measurement model, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) per sample were estimated, first. The results of EFA and CFA were compared between countries to prove information on whether the measurement instrument was perceived similarly by students from different countries. Then, Cronbach's alpha and composite reliability (C.R.) coefficients were checked whether they were above 0.70 to achieve internal consistency of each factor. In addition, as Fornell and Larcker (1981) recommended, convergent and discriminant validity of the measures were examined. According to Fornell and Larcker (1981), in order to ensure convergent validity, the average variance extracted (AVE) value should be higher than 0.50. Also, to confirm discriminant validity, a squared root value of AVE for each latent construct should be higher than each latent constructs' highest correlation.

After confirming the reliability and validity of the core constructs, we merged the datasets from different countries and conducted a measurement invariance (MI) test before a latent mean comparison between the intervention and non-intervention groups. MI ensures that constructs are measured similarly across groups and that the latent means of the constructs are comparable (Moreira et al., 2018). The MI test was conducted sequentially by comparing nested models. First, configural invariance was estimated to confirm that the variables measured the same constructs across groups. This MI model was estimated without any parameter constraints. Second, a metric invariance test was conducted by constraining all factor loadings across groups and comparing model fit between the configural and metric invariance models. If there are no significant differences, the measures are considered to be on the same scale. In the last step, scalar invariance was measured by constraining all factor loadings and item intercepts across groups. Then, the model fit of scalar invariance was compared to the fit of metric invariance. If no significant differences are found across groups, latent factor means are allowed to be compared across groups. Therefore, it was necessary to achieve scalar invariance to conduct a latent mean analysis (LMA) between the intervention and the non-intervention groups.

The scalar invariance model was used in which the latent mean of the intervention group was set equal to zero and the latent mean of the non-intervention group was freely estimated in order to measure the latent factor mean difference between the intervention and non-intervention groups (Brown, 2015). Finally, in order to investigate whether the relationship between attitude and aspiration was enhanced by awareness, latent moderated structural equation modeling (LMS) was used (Klein & Moosbrugger, 2000). Compared to manifest analyses, LMS indicates some advantages in analyzing moderation effects such as controlling for measurement errors and accounting for the non-normality of the variables by providing robust standard errors. As shown in Table 10, latent regression models were estimated first, and then latent interaction terms were entered into the latent regression models to measure the moderation effect of the two awareness factors, preparation and information. However, in this statistical model, we did not put the two interaction terms together in the same statistical model since the effects of preparation and interaction might not be separable as both of them represented awareness of science careers and thus may indicate an interaction effect between the two moderators. Therefore, we tested separate main effects of the two moderators for concentrating solely on the moderation effects rather than the interaction of the two moderators.

Mplus 7.4 was used with the maximum likelihood with robust standard errors and a chi-squared estimator (MLR) which is robust to non-normality, and missing data were estimated using full information maximum likelihood estimation (FIML) (Muthén & Muthén, 2012). In measuring the goodness of model fit, traditional cut-off values were applied: RMSEA (the root mean square error of approximation) below 0.05 or 0.08, SRMR (standardized root mean square residual) below 0.08; CFI (comparative fit index) and TLI (Tucker Lewis index) above 0.90 or 0.95 (Wang & Wang, 2012). However, Mplus does not provide fit indices for the LMS yet.

Result

Validity and Reliability of the Three Constructs Between Countries

According to the EFA result, 16 variables formed four factors loaded greater than 0.6 as expected for all three countries as shown in Table 4. Similarly, the CFA results with four latent constructs showed a good model fit and indicated that the values of factor loading were 0.61 to 0.93 exceeding the criterion of 0.50 (Hair et al., 2006), which proves good construct validity of this measurement (see Table 5). Regarding the convergent and discriminant validity, the AVE values were higher than 0.50, and each squared root value was higher than the highest correlation of each correlation value between latent variables, as shown in Table 6. Regarding the reliability, the C.R. and Cronbach alpha values were all higher than 0.70. Therefore, this measurement demonstrated satisfactory reliability and validity. Since the measurement indicated acceptable validity, reliability, and the same structures for all three countries, we combined data for further analyses.

Table 4 Results of EFA for each country

	Germany				Finland				Estonia			
	1	2	3	4	1	2	3	4	1	2	3	4
Interest 1	0.720				0.788				0.709			
Interest 2	0.755				0.745				0.720			
Interest 3	0.801				0.844				0.785			
Interest 4	0.832				0.739				0.780			
Interest 5	0.709				0.755				0.799			
Aspiration 1		0.813				0.756				0.820		
Aspiration 2		0.823				0.765				0.828		
Aspiration 3		0.877				0.833				0.760		
Aspiration 4		0.821				0.807				0.800		
Preparation 1			0.795				0.860				0.671	
Preparation 2			0.779				0.864				0.621	
Preparation 3			0.854				0.884				0.757	
Preparation 4			0.755				0.862				0.751	
Information 1				0.822				0.721				0.830
Information 2				0.813				0.843				0.778
Information 3				0.806				0.818				0.808

Table 5 Results of CFA for each country

	Germany				Finland				Estonia			
	1	2	3	4	1	2	3	4	1	2	3	4
Interest 1	0.836				0.823				0.819			
Interest 2	0.670				0.736				0.822			
Interest 3	0.917				0.893				0.866			
Interest 4	0.829				0.742				0.806			
Interest 5	0.800				0.777				0.741			
Aspiration 1		0.898				0.804				0.925		
Aspiration 2		0.911				0.880				0.925		
Aspiration 3		0.881				0.788				0.853		
Aspiration 4		0.808				0.819				0.905		
Preparation 1			0.756				0.811				0.732	
Preparation 2			0.791				0.856				0.625	
Preparation 3			0.846				0.869				0.609	
Preparation 4			0.668				0.822				0.708	
Information 1				0.812				0.694				0.745
Information 2				0.683				0.805				0.854
Information 3				0.742				0.719				0.723

Table 6 Validity and reliability

	Cronbach's alpha	CR	AVE	Interest	Aspiration	Preparation	Information
Interest	0.91	0.90	0.65	**0.81**			
Aspiration	0.70	0.92	0.73	0.76	**0.86**		
Preparation	0.80	0.88	0.64	0.30	0.23	**0.80**	
Information	0.79	0.78	0.54	0.45	0.47	0.36	**0.74**

Measurement Invariance

Concerning measurement invariance between the intervention and non-intervention groups, we compared the three measurement models—configural, matric, and scalar. As shown in Table 7, the configural model showed an acceptable fit providing adequate support for configural invariance of the measurement between the intervention and control groups. Also, concerning the model comparisons between the three models, all the goodness-of-fit values remained the same; that means that the changes of CFI, RMSEA, and SRMR were much smaller than 0.01, 0.015, and 0.015 for CFI, RMSEA, and SRMR, respectively (Cheung & Rensvold, 2002). Thus, these results supported the measurement invariance across the two groups.

Mean Comparisons Between the Intervention and Non-intervention Groups

After confirming reliability, validity, and MI, we first checked observed mean values for each country including both intervention and non-intervention groups before comparing the latent mean differences. As shown in Table 8, the observed mean values of interest and preparation were higher than the midpoint 2.5, while the mean values of aspiration and information were lower than the midpoint in most cases. Regarding the latent mean differences, as expected, the intervention group indicated

Table 7 Measurement invariance across groups (intervention and control)

Model	χ^2 (*df*)	CFI	RMSEA	SRMR	$\Delta\chi^2$ (Δdf)	ΔCFI	ΔRMSEA	ΔSRMR
Configural	360.85 (196)	0.972	0.047	0.038				
Matric	370.39 (208)	0.973	0.046	0.040	7.03 (12)	0.001	0.001	0.002
Scalar	424.71 (220)	0.965	0.050	0.043	59.35 (12)*	0.008	0.004	0.003

*$p < 0.05$

Table 8 Descriptive (scale range between 1 and 4)

Factor	Observed mean (SD)	Germany	Finland	Estonia
Interest	2.52 (0.77)	2.67 (0.82)	2.38 (0.71)	2.64 (0.79)
Aspiration	2.10 (0.89)	2.24 (0.96)	1.97 (0.80)	2.19 (0.96)
Preparation	2.84 (0.66)	2.63 (0.68)	2.92 (0.65)	3.04 (0.55)
Information	2.29 (0.73)	2.25 (0.76)	2.30 (0.68)	2.34 (0.81)

Table 9 Latent mean comparisons between intervention and control groups

Factor	Intervention – control	Effect size (*d*)
Interest	0.17**	0.22
Aspiration	0.25***	0.27
Preparation	0.01	0.02
Information	0.21***	0.30

**$p < 0.005$

***$p < 0.001$

a higher interest, aspiration, and information than the control group while there was no significant difference in the preparation construct as presented in Table 9.

Moderation Effect of Awareness on the Relationship Between Interest and Aspiration

In order to investigate the moderation effect of awareness, we conducted LMS, and the result showed that both preparation and information moderated the effects of interest on future career aspirations positively (Table 10). That is, a significant ordinal interaction between interest and awareness was substantiated when predicting career aspiration. In other words, the positive effect of interest on aspiration increased when preparation and information were high. Figure 1 clearly depicts that while interest always positively predicts aspirations, the effect becomes stronger at high preparation and information (+ 1 SD) compared to the low ones (− 1 SD). However, the moderation effect of information ($b = 0.24$, $p < 0.001$) was comparably higher than preparation ($b = 0.08$, $p < 0.005$).

Table 10 Latent moderated structural question modeling

Model	M 1.1	M 1.2	M 2.1	M 2.2
Variable	b (SE)	b (SE)	b (SE)	b (SE)
Interest	0.76***	0.75***	0.82***	0.67***
Preparation	0.01	0.02		
Interest × preparation		0.08**		
Information			0.24***	0.18***
Interest × information				0.13***
Gender	−0.03	−0.01	−0.02	−0.004
R^2	0.57	0.58	0.59	0.61
Model fit				
χ^2	207.55		222.07	
df	74		62	
RMSEA	0.049		0.059	
CFI	0.974		0.965	
TLI	0.968		0.956	
SRMR	0.028		0.033	

**$p < 0.005$

***$p < 0.001$

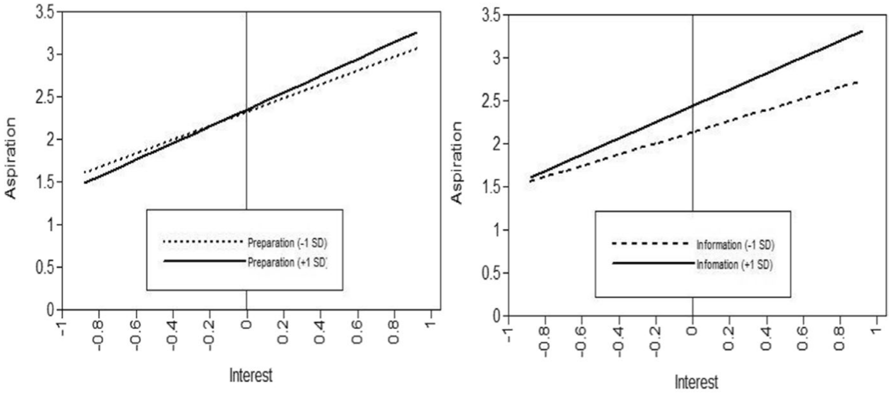

Fig. 1 Interaction effects of awareness (preparation and information) and attitude on aspiration

Discussion

Students' interest in science indicates a positive relationship with their aspirations in science careers. However, during the last decades, students have shown a negative trend in their interest in science, negatively affecting their aspirations towards science careers. Also, much research points out that not only low interest in science but also insufficient awareness or misconception about science careers led students away from science careers in future. Accordingly, the MultiCO project aimed to promote students' awareness and attractiveness of science careers in order to increase their aspiration towards science studies and careers by introducing real-life-related, science career-focused scenarios at lower secondary school as embedded careers education in science lessons.

According to the results, students who experienced the embedded careers education during the two and half years at lower secondary school showed a higher interest in science compared to those who were not involved in the project. This result is in line with the previous studies emphasizing the use of relevant science education to foster students' interest in science (Kang & Keinonen, 2018; Potvin & Hasni, 2014; Stuckey et al., 2013). As depicted, the used career-related scenarios were meant to be such that the careers are introduced in a context that is familiar and relatable to the student. In this project, students also participated in the scenario development processes and indicated that the scenarios were interesting and relevant to their lives (Kang et al., 2019). Thus, these scenario interventions drew students' attention to science-related careers and contexts so that they can enjoy science courses at school. In addition, science aspiration was higher in the intervention group than in the non-intervention group. This result is in accordance with the previous research indicating that science and technology career interventions increase students' motivation (Basl, 2011; Potvin & Hasni, 2014). Our results also showed a high correlation of aspiration with interest and a moderate correlation with awareness, especially career information given by the school. Therefore, the increase of science aspiration is attributed to the increase of interest and awareness of science careers that the MultiCO project aimed at. As argued by Blotnicky et al. (2018), career interest is highly time-sensitive, while students' interest in science careers decreases between the age of 13 and 15. Also, Tai et al. (2006) found that students who expected to work in the science-related fields in future got a bachelor's in biological science 1.9 times higher and physical science degree 3.4 times higher than students who did not have any expectations in science careers when they were in the lower secondary school. Thus, introducing several science careers during lower secondary school years might play a pivotal role in sustaining or increasing young students' attention and retention to science careers for future.

The embedded science career interventions also increased students' awareness of science careers. In addition, awareness of science careers moderated the positive effect of interest on aspiration. That is, when students get more information about science careers, their interest in science is more easily transferred to their aspirations in science studies and careers. Thus, this result points out the critical role of awareness of science careers in fostering students' aspirations during the lower secondary school years. This is achieved by introducing students to several unfamiliar scientific or science-related career opportunities (e.g., horticulturist, forensic, biochemist, engineers), giving them chances to interact with scientists, or correcting their misconceptions and/or stereotyped perceptions of more familiar scientific careers (e.g., doctor, chemist) (Drymiotou et al., 2021; Salonen, 2020). Also, the introduced careers need to be engaging and appropriate for students and include various academic levels (e.g., electrician, electrical engineer). However, at the same time, science teaching and learning need to maintain or increase students' interest in science by giving them opportunities for active engagement in inquiry practices through relevant contexts (Drymiotou et al., 2021) since science education prepares students for science-related careers with knowledge and skills (Bennett & Holman, 2002). Blotnicky et al. (2018) also indicated that "a greater emphasis on authentic means of teaching and evaluating STEM content that involves collaboration, problem solving, and application of STEM knowledge might serve to engage learners in more meaningful ways, thereby enabling continued motivation and interest in STEM careers as students progress through secondary and post-secondary education" (p. 13). Interestingly, our results also show that being informed is more important than being prepared. For instance, the participating students were answered that their school science subjects prepared them well to equip with the basic skills and knowledge for science-related careers (2.84 out of 4) while they perceived that they were not well informed about how to find the relevant information and what steps they need to take to pursue science-related careers (2.29 out of 4). However, the preparation construct was not significantly correlated to aspirations whereas the information construct indicated not only a positive relationship but also moderating effect on science-career aspirations (Table 10). Similarly, Basl (2011) reported that the information construct predicted science aspirations two times higher than the preparation construct in the Czech Republic, Germany, and Norway. Therefore, considering the aspiration towards these careers, it is not enough to equip students only with scientific knowledge and skills; more important is to make visible the career steps and required competencies in science-related careers. Thereby, the students can see and make connections to their own competencies and further in their study and career choices.

In this regard, as shown in Table 9, this project was successful as it increased the participants' perception of being informed about science-related careers compared to the non-participants. Thus, it is highly recommended for science teachers to consider the embedded careers education in their teaching. As our results show, the intervention does not have to happen all year round; implementing this approach (just) twice a year may produce a meaningful result concerning students' perception of being informed. Although it is hard to say that those five interventions during the two and half years were the only reason that increased students' awareness of science careers, we argue based on the four-phase model of interest development by Hidi and Renninger (2006) that students who experienced and were inspired by the scenarios at school (triggered situational interest) were intrinsically motivated to know more about science and science careers (maintained situational interest) so that they might spend more time on searching about science careers (emerging individual interest) and that they indicated higher awareness of science careers (well-developed individual interest) than those who were not exposed to the scenario interventions. Thus, in order to increase the number of students who intend to work in science-related fields in future, it is important to consider not only interest in but also awareness of science careers, since career exploration is the first step to develop students' vocational identity (Porfeli & Lee, 2008). However, since our data do not provide information concerning this process of interest development, more qualitative and longitudinal research is needed.

As is known, students start to consider their future careers earnestly during the lower secondary school years and to decide whether to study advanced science subjects at this point. Concerning that a science education at college often requires someone to have studied science subjects at upper-secondary school, this early aspiration to study and work in science-related fields during the lower secondary school may enhance or restrict future career options (Kang et al., 2019; Sheldrake et al., 2019). Thus, increasing awareness of science careers at the lower secondary school is critical to students' future career choices in science. This early exploration is also important in terms of retaining students' commitment to science careers as early encounters with science careers will continue to have an effect on the career development process of the student in the future. One way to increase students' awareness of science careers is to introduce embedded careers education in science lessons at school using real-life, authentic science career-focused modules as this project conducted (Archer et al., 2013; Drymiotou et al., 2021; Reiss & Mujtaba, 2017). However, as reviewed, science teachers are reluctant to inform students about science careers mainly due to their lack of information and experiences in authentic science careers (Mansour, 2015; Watermeyer et al., 2016). Thus, science teachers might need information and materials that are relevant to their current situation, and for this, ongoing systematic support given by multi-stakeholders should be continued.

Although this project gives several educational implications, however, this study is not without limitations. First, since our samples do not represent the population of each country, the results cannot be generalized. However, we tried to recruit different types of schools in different areas that may represent other schools in the same country. For instance, in Germany, we selected the three schools, one from a rural area, the other from the city area, and the one for girls only school. Thus, we expect that similar results may be found in the other provinces of Estonia, Finland, and Germany if we could conduct the same study there. Second, since we did not use a true experimental design and did not have pre-test measurement, it is hard to know whether there were initial differences in interest, aspirations, and awareness between the experimental and control groups. However, as described, students of both groups were in the same schools and no participating schools used student selection processes in assigning students in different science classrooms. Thus, there were no reasons to make differences between the experimental and control groups in their attitude towards science. However, since it may limit the interpretation of the results, it is highly recommended to use pre-measurement in conducting the quasi-experiment for comparison studies for further research. Third, although we controlled the effect of gender, there can be other factors that may affect interest, awareness, and aspirations such as different types of career guidance policy at each country or teacher-related factors as a systematic factor or socioeconomic status, race, and self-efficacy as internal factors. Thus, it is recommended to include and control those factors for further research.

In conclusion, students need knowledge about career opportunities to be able to make informed choices. Thus, providing students with information and advice about career options and the corresponding educational requirements is seen to be critical. However, many students face a shortage of opportunities to explore science careers. Also, teachers indicate a lack of knowledge and experiences in science careers that make them reluctant to introduce authentic science careers to students at school. Our project introduced an attainable solution that provides students with an opportunity to experience authentic science careers and that may complement science teachers' inexperience through the embedded model of careers education in science lessons.

Appendix

Results of EFA for the UK and Cyprus.

	The UK			Cyprus		
	1	2	3	1	2	3
Interest 1	0.826			0.763	0.441	
Interest 2	0.639			0.600	0.562	
Interest 3	0.798			0.709	0.519	
Interest 4	0.784			0.633	0.586	
Interest 5	0.767			0.518	0.485	
Aspiration 1	0.855			0.789		
Aspiration 2	0.862			0.858		
Aspiration 3	0.861			0.868		
Aspiration 4	0.797			0.864		
Preparation 1		0.786			0.830	
Preparation 2		0.838			0.855	

	The UK			Cyprus		
	1	2	3	1	2	3
Preparation 3		0.788			0.766	
Preparation 4		0.873			0.673	
Information 1			0.793			0.684
Information 2			0.820			0.908
Information 3			0.803			0.795

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