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Upper secondary students' situational interest in physics learning in Finland and Chile

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ABSTRACT

This study examines how classroom activities, student gender and student personal interest in science studies and careers predict situational interest in physics learning. Teaching modules were designed based on the secondary physics curricula in Finland (Helsinki) and Chile (Santiago and Viña del Mar) emphasising students engagement in scientific practices. The study was implemented in four classrooms in both countries. Data on situational interest and ongoing classroom activities were obtained using the experience sampling method, with measurements taken three times during a lesson. The process yielded a total of 1717 measurements in the Finnish schools and 1767 in the Chilean schools. Multilevel regression analyses with mixed effects and random intercept were conducted. Results showed a positive effect of scientific practices that required asking questions, designing scientific inquiry and interpreting data on situational interest. Student collaborative situations were more interesting for Chilean students than for Finnish ones. In terms of gender differences, on average, Finnish male and female students experienced the same level of situational interest, while the situational interest of Chilean female students was higher than the average of male students. Personal interest in science studies and careers was the best predictor of situational interest in both countries.

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Introduction

Enhancing interest in science learning and pursuit of science careers has been an important component of education policy and policy implementation for decades (European Union, 2016; Fensham, 2009). However, in many countries student interest in physics and science-related careers has not increased (Christidou, 2011; DeWitt & Archer, 2015; Osborne & Dillon, 2008; Zeyer et al., 2013) despite of a large amount of research

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and development projects (Linnenbrink-Garcia et al., 2013; Swarat et al., 2012). Potvin and Hasni (2014) argue based on their systematic review that most of these projects have not succeeded in supporting the development of interest (Renninger & Hidi, 2011). Consequently, there still is a need for studies that focus on how students' interest in physics learning at the upper secondary level may be developed, including appropriate measures of interest.

Most physics-related interest studies are based on surveys or interviews (Krapp & Prenzel, 2011). However, surveys and interviews have limitations because they are based on retrospective measures of students' reported interest or personal type of interests (Ainley & Ainley, 2011; Tuominen-Soini & Salmela-Aro, 2014; Hampden-Thompson & Bennett, 2013). This suggests the need to study interest in physics learning as raised in actual teaching situations or what is described as 'situational interest' (Palmer, 2009). Moreover, assumptions that female students are less interested in science learning, especially physics, are typically based on surveys instead of measurements in real situations. Thus, measurements in real situations could offer insights into how different students' situational interest varies during physics learning.

This article contributes to the knowledge on student interest in physics learning. To this end, it presents results of studies carried out in two very different education contexts – Finland, and Chile. We studied students' personal interest in science through their responses to survey. Situational interest in turn was examined through experience sampling method (ESM; Csikszentmihalyi & Schneider, 2000). The studies examined also the influence of gender to situational interest. To this end, specific teaching modules in line with national curricula were developed in both countries and enacted by teachers in the classrooms during the study period. In Chile, the focus of its modules was on integrated physics and biology and in Finland on project based learning in physics. Both approaches required active student involvement during lessons. Beyond these curricular differences, the study in both countries shared a common theoretical framework as well as similar data collection and analysis procedures. The following research questions guided the studies.

1. How frequently do students in the Finnish and Chilean contexts engage in scientific practices such as asking questions, designing scientific inquiry, collaborating; and in traditional activities, such as listening, writing and calculating?
2. What is the level of situational interest elicited in these different type activities?
3. How do teaching/learning activities, student gender and student personal interest in science studies and careers predict situational interest in physics learning?

As will be described in what follows, both research cases provide findings which are similar and independent of the teaching module content and particularities of the education contexts in which they were enacted. However, we are not comparing the results in a traditional way.

Literature review

Interest, motivation, engagement and attitude are used in the context of school education to describe factors related to teaching and learning that arouse, maintain or cancel

student learning or work related to the curriculum aims. However, these variables do not operate in the same way as it is possible, for example, that a person be motivated but not interested in an ongoing activity (Renninger et al., 2018). In terms of interest, which is one of the key concepts of this paper, its definitions vary from those of other similar constructs on account of its object-, content- or domain-specific nature (Krapp & Prenzel, 2011; Renninger & Hidi, 2011). For example, Schiefele (1999) defined interest as a ‘content-specific motivational characteristic’, Krapp (2007), in the context of person-object theory of interest, described interest as content-specific while Renninger and Hidi (2011) referred to it as an activity-specific motivational variable influencing student learning. For the purposes of the study reported in this article, we describe interest as emerging from the interaction of a person with his or her environment and as dependent on content, topic, event or activity occurring during teaching-learning situations (Hidi & Renninger, 2006; Krapp & Prenzel, 2011).

Personal and situational interest

Interest can be approached from two main perspectives: as a person’s characteristic (personal interest) and as a psychological state aroused by specific traits in the learning environment (situational interest). Personal interest is associated with a person’s prior knowledge and is topic-specific (topic interest), it develops slowly and tends to have long-lasting effects on a person’s knowledge and values (Guthrie et al., 2006). According to Schiefele (1999), personal interest consists of two kinds of valences: feeling-related and value-related. Feeling-related valences are stimulated by the nature of a topic, such as feelings of enjoyment and involvement. Value-related valences arise from attribution of personal significance, importance or usefulness to an object or activity such as science learning or working in a science or technology career.

Situational interest in the context of science teaching is typically aroused as a function of how interesting a topic or activity may be or how useful study of the topic might be perceived from the perspective of future science studies or career (Abrahams, 2009; DeWitt & Archer, 2015; Habig et al., 2018; Hasni et al., 2016; Häussler, 1987; Hoffman, 2002; Jones et al., 2000; Lin et al., 2013; Osborne et al., 2003; Palmer, 2009; Potvin & Hasni, 2014; Stuckey et al., 2013; Tzu-Ling, 2019; Zeyer et al., 2013). Situational interest can be a changeable, malleable experience that occurs over time and varies in intensity across different domains and situations. Moreover, it is partially under the control of teachers (Hidi & Renninger, 2006; Krapp & Prenzel, 2011). Interest caused by something in the environment is called ‘triggered situational interest’. Once interest is triggered, it may develop into ‘maintained situational interest’ if it is held long enough, and becomes more integrated with cognition (Hidi, 2006). As far as physics learning is concerned, Häussler (1987) suggested that there are three dimensions related to situational interest: interest in a particular topic, in a context and in the activity (e.g. a scientific practice). These three dimensions have been used in many studies (e.g. Hunsu et al., 2017). More specifically, referring to distinctions between an individual or personal interest and situational interest, the study by Rotgans and Schmidt (2018) concludes that while personal interest has an influence on situational interest at the beginning of a task, it ceases to be important later and is not a significant predictor of learning compared to the situational interest which is so.

Development of interest in the context of inquiry-based science learning

According to Renninger et al. (2015) seeking answers to questions or problems better supports the development of interest than just receiving information. Consequently, the use of scientific practices such as asking questions or modelling (Inkinen et al., 2020), could contribute to the development of situational interest. On the other hand, the lack of a common definition (Anderson, 2007; Minner et al., 2010), makes it difficult to analyse and compare interest-related research outcomes in the context of inquiry-based science learning studies.

The use of scientific practices is an important theme in learning sciences research. Krajcik and Czerniak (2013) thus hold that students are not able to learn disciplinary content without engaging in scientific practices and actively constructing their understandings through work and use of ideas in real-world contexts. Scientific practices are similar to expert performance in the discipline. They involve asking questions, planning and carrying out investigations, analysing and interpreting data, developing explanations and building models based on the data. Scientific practices are not the same as inquiry, nor do they replace inquiry. They rather consist of a combination of activities in teaching and learning situations (Miller et al., 2018).

Research on the effects of project based learning (PBL) and inquiry-based science learning (IBSL) over student interest yield different results. Potvin and Hasni (2014) conducted a review of 228 articles published between 2000 and 2012 on interest, motivation and attitude towards upper-secondary school science and technology. Eight of these articles examined the influence of PBL and IBSL on students' interest in science learning. However, only two of the articles reported an improvement in interest. This was rather unexpected because PBL and IBSL offer choices for students, for example, in the planning of investigations, and the availability of options has been recognised as supporting the development of interest (Linnenbrink-Garcia et al., 2013). In fact, Swarat et al. (2012) argued that students' active or hands-on roles do not necessarily support the development of topic interest. On the other hand, a study by Kanter and Konstantopoulos (2010) on the implementation of PBL curricula in urban schools found that students' attitudes towards science did improve. Likewise, Renninger et al. (2019) reported that activities within IBSL or PBL that involved collaboration, autonomy, challenge, use of computers and personal relevance could trigger interest. Krajcik and Blumenfeld (2006, p. 318) also indicated that inquiry-based or project-based curricula supports the development of interest in the case of real and meaningful topics that are important to students.

Other factors affecting situational interest are collaborative/cooperative learning approaches as gleaned from Potvin and Hasni's (2014) systematic review of research articles. Eight of the reviewed articles recorded positive results of collaboration for students' interest. Singh et al. (2002) also argued that the development of interest could be supported by social interaction and collaboration situations. Hidi and Harackiewicz (2000) assert that working with others enhances situational interest that further triggers personal or individual interest. Collaboration also provides an opportunity for students to experience disequilibrium which in turn may arouse curiosity and interest (Turner, 1995). However, while collaborative forms such as cooperative learning are motivating practices, their effect on learning needs to consider the role of mediating factors such as cognitive processing, helping behaviour and teaching variables (Bossert, 1988).

Context and interest

Most context-related interest studies report positive effects of context over the development of situational interest, in that they provide an opportunity for authentic problems or situations to arise (Bennett, 2016; Gilbert, 2006). In context-based approaches, students become familiar with a science topic through activities that allow them to connect the topic to everyday situations and human activities, and allow them to see the relevance of the topic for their individual and societal lives or future professions (Stuckey et al., 2013). But also, the use of scientific practices or inquiry in school science conveys the idea that science needs to be studied in a professional context (Anderson, 2007; European Union (EU), 2004). In analysing the influence of science- and technology-related working contexts over students' situational interest in two different projects, Habig et al. (2018) found that personal, societal and professional contexts influenced the development of situational interest.

Gender and interest

Many researchers argue that female students are less interested than male students in physics and that student interest in physics decreases with age (Hoffman, 2002; Renninger et al., 2015). One reason for this difference is that female students see themselves as having fewer opportunities to engage in science and science careers than boys (Aschbacher et al., 2010). Another reason is that in science and engineering there are fewer female role models than male ones. Lack of female role models affects not only female student identity but also their possible identity as a scientist (Settles et al., 2009). As a consequence of these experiences and influences, male and female students differ regarding, which scientific topics are of interest to them. For example, technological contexts are of less interest to female students than to male students, while personal contexts such as health and societal ones seem more or equally interesting to females compared to males (Jones et al., 2000; Osborne et al., 2003). The reasons for gender differences in physics are multifaceted. Tzu-Ling (2019) indicates that gender differences could be explained by several background variables, such as family socioeconomic status, learning experiences (i.e. teachers, peer interaction, curriculum, and assessment) and family influences and expectations.

Research design and methods

The focus of the study was on students' interest in physics learning in line with the new upper secondary science curricula enacted in Finland (FNBE, 2015) and in Chile (MINEDUC, 2019). The Finnish upper-secondary physics curriculum emphasises the learning of transversal competences, core concepts and scientific practices and suggests that the development of student interest be supported by active participation in knowledge acquisition (cf. Krajcik & Shin, 2015). The Chilean upper secondary physics curriculum promotes the development of skills related to observing and asking questions, planning and conducting research, processing and analysing evidence, evaluating and communicating (MINEDUC, 2019). Both curricula emphasise the contextualising of learning and students' engagement with real scientific and engineering practices (cf.

Krajcik & Shin, 2015) as well as collaboration. Also common to both curricula is the importance given to contextualising and making physics learning relevant for students.

The study have been organised in the context of the educational design research (EDR) (Sandoval, 2014). In order to make research on situational interest, we first designed teaching modules in Finland and in Chile. We have described the rationale behind the design of the module, especially, what is known about the development of situational interest. In both countries, we implemented first a trial and practised the module and data collection with teachers. Finally, the developed modules were implemented to four schools in both cities and, therefore, the selection of the classrooms was convenience type. We explain the research process and design below.

The curricular materials

Both studies used specific curricular approaches of which we include examples in the appendix. The Finnish study used a teaching module centred on key features of project-based learning (Krajcik & Blumenfeld, 2006) covering four 75-min periods. The module guided students to become familiar with models that describe the movement with constant and changing velocity and the reasons why velocity changes. The module supported contextualising through means of a driving question and demonstration aimed at supporting understanding of the driving question: ‘Why do some objects take the same amount of time to fall from the same height while others do not?’ The purpose of this demonstration was to encourage students to pose relevant research questions and plan investigations in order to make sense of phenomena and work collaboratively in small groups (Schneider et al., 2020). While engaging in scientific practices, students were guided to interact socially, to collaborate and use learning technologies, and were guided in the development of a final product or artefact, resulting from their work, such as a science model, which describes the phenomena under study. These student products became publicly accessible external representations of their learning. Also, during the learning process, students were scaffolded to participate in activities normally beyond their ability (Krajcik & Czerniak, 2013) (See example in Appendix).

In Chile, the study and its contextualisation were based on a specially developed teaching module, which focused on physics, and integrating also concepts from biology, mathematics and technology (Ossandón & Uribe, 2019), taught over four 90-minute lessons. The module focused on the development of the Interdisciplinary Science Inquiry (ISI) competences, emotional engagement (Csikszentmihalyi, 1990) and scientific practices (Osborne, 2014). The module emphasised flexible and inclusive learning environments and integration of hard- and life-science learning. The teaching activities required utilisation and connection of prior knowledge in multiple science-related fields. Student engagement was sought through involvement in scientific and engineering practices, student collaboration and construction of artefacts in inquiry and problem-solving situations (see example in Appendix).

Context and participants

In Finland, the study was conducted by physics teachers in upper secondary schools in the downtown area of the city of Helsinki. A total of 106 students (62 female, 44

male) who were taking their first upper secondary physics course participated in the study. Students' ages varied between 15 and 17 years. In Chile, the study was conducted in the cities of Santiago and Viña del Mar. Four physics teachers (three male and one female) worked with a total of 157 ninth-grade students in four classes (72 female, 85 male). Student ages varied between 14 and 17 years. Two of the classes were mixed gender, one was all girls and the other was all boys. Two of these schools were selective and two were not.

Procedures

Two types of instruments were used in both locations: (a) a student questionnaire indicating personal interest in science studies and careers and (b) an ESM instrument, used for measuring students' situational interest. The student questionnaire included interest items from the 2006 PISA Student Questionnaire (OECD, 2005), which have been recognised as valid in different education contexts (Toma, 2020). The student questionnaire items aimed at getting value-related indications of personal interest in science learning and studies (Wigfield & Eccles, 2000). For example, students were asked about their interest in science studies and pursuing science careers, such as: 'Physics is important to me personally' or 'What I learn in my physics class is important because it will help me in my future career options'. Students answered by ticking the appropriate box on a four-point Likert scale ranging from 1 (*strongly agree*) to 4 (*strongly disagree*).

On the assumption that student situational interest is triggered, maintained or supported by what occurs in the teaching situation, such as the use of scientific practices and collaboration, we used experience sampling method (ESM) (Zirkel et al., 2015). ESM seeks to get at students' moment-to-moment situational interest regarding the learning activities in which they were involved (Csikszentmihalyi & Schneider, 2000). In order to capture this situational interest, students were provided with smartphones with pre-recorded questions to be responded following beeps during the lessons. The questions addressed the following: (a) what students were actually doing and with whom they were working when the phone beeped (i.e. listening, writing, calculating alone, with others, the teacher); (b) what kind of activities were they involved in at the time of the beep (i.e. asking questions, planning investigations, interpreting data, solving problems). Situational interest was measured by means of the question 'Is the activity interesting?', using a four-point Likert scale ranging from 1 (*not at all*) to 4 (*very much*). Students were prepared beforehand for ESM and teachers were assisted, if needed, during the implementation of the module.

Data collection

Prior to data collection, pilot trials of the system were carried out in both countries which enabled some minor corrections to the administration procedures to be enacted, mostly related to clarifying terms used.

The questionnaires on students' personal interest in science was administered to all participants in the Finnish study prior to beginning the set of experimental lessons. In Chile, the questionnaire was administered after completion of the lessons,

In both country contexts, students answered the ESM questionnaire three times in each lesson. The phones were set to beep about 10–15 min after the beginning of the lesson, in the middle of the lesson, and about 10–15 min before the end of the lesson. Teachers knew this timing of the data collection. In Finland, data collection took place during five 75-minute lessons and in Chile during seven 90-minute lessons.

There are several threats to the validity and reliability of ESM questionnaires (Hektner et al., 2007). In a traditional survey, to increase the validity and reliability of the measurement, several items, a scale, may be used to measure a psychological construct, such as interest. In the ESM questionnaire, there was only one question that asked ‘Are you interested in what you did?’ This type of question asks the student to focus on the topic or activity going on at the moment, as emphasised in the POI theory (Krapp, 2007). In order to support students’ understanding of the questions related to the scientific practices, they were introduced to the students at the beginning of the teaching module. Moreover, teachers were advised to indicate the name of the practice during data collection in order to support students’ recognition of the scientific practice when beeped. The number of answers and the response rate are important metrics in ESM studies (van Berkel et al., 2018). In order to increase the validity of the study, we collected a total of 1,717 ESM answers in Helsinki and 1,767 ESM answers in Chile. In both cities, the response rate was more than 80%.

Data analysis procedures

Analysis of the survey: Following factor analysis of responses to the eight survey items in both country locations, only one factor was retained (principal axis factoring with varimax rotation) with high item loadings (0.83–0.84 for the Finnish data and 0.75–0.81 for the Chilean data). The factor was labelled ‘student personal interest in science studies and careers’. It was thus possible to reduce the data and calculate a sum variable based on the items. This sum variable was further used to predict students’ situational interest in the regression analysis. Examples of the items and mean values by gender are in [Table 1](#) below.

Analysis of the ESM data: In order to reduce the number of scientific practices in the analysis, we combined them in three groups according to the PISA scientific literacy competence model (OECD, 2013): (1) ask questions and design scientific inquiry (asking questions, planning investigations and conducting investigations), (2) interpret data and evidence scientifically (developing models, analysing data, constructing explanations, making arguments), and (3) explain phenomena scientifically (using models, solving problems, evaluating information). Other variables used in the analysis were: (4) collaborating in a small group (working in a group), (5) listening, (6) writing and (7) calculating ([Tables 2](#) and [3](#)). Frequencies of the various activities and of students’ self-reports on situational interest while engaging in learning activities in both locations are presented in [Table 2](#), according to research questions one and two. In order to answer the third research question and predict situational interest, three groups of scientific practices, collaboration, traditional science learning methods, listening, writing and calculating, and student gender and personal interest in science studies and careers, were used in multilevel regression analysis with mixed effects and random intercept. The ESM data of the study is hierarchical, meaning the situational observations are nested within students. To examine the

Table 1. Example of items used for measuring student interest in physics studies and physics-related careers.

	Male		Female		t-test	
	Mean	SD	Mean	SD	t	p
<i>Helsinki</i>						
I will use physics in many ways when I am an adult.	3.04	0.64	2.94	0.64	3.0	0.003
Physics is important to me personally.	3.33	0.73	3.03	0.82	8.2	0.000
What I learn in my physics class is important for me because I need this for what I want to study later on.	3.41	0.71	3.21	0.86	5.1	0.000
<i>Chile</i>						
I will use physics in many ways when I am an adult.	2.95	0.68	2.97	0.81	-0.18	0.861
Physics is important to me personally.	2.96	0.67	2.79	0.86	1.3	0.196
What I learn in my physics class is important for me because I need this for what I want to study later on.	2.64	0.81	2.41	0.95	1.52	0.130

Scale: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree.

nestedness of the data, intraclass correlations (ICC) for the outcomes were first calculated. Second, a linear mixed-effect model was estimated to predict situational interest with situational activities and with students' gender and overall interest in science and related careers. The mixed-effect model allowed us to partition the variability in interest into a part that varies between individual (which can be predicted by fixed individual characteristics, such as gender and overall interest in science), and a part that varies within individual, which can be predicted by characteristics of the situation, such as the specific tasks the student is engaged in. The parameters were estimated separately for each sample (Finland and Chile) using multilevel regression with maximum likelihood estimation. All the analysis was run within the R environment (Finch & Bolin, 2017). The results of the regression analyses are presented in Table 3.

Table 2. Type of activity students reported experiencing in a randomly selected variety of situations during physics lessons in Helsinki and Chile, and average self-report of the level of situational interest during each activity.

	Helsinki			
	f	%	Level of situational interest (1-4)	Std. Deviation
Scientific practices situations				
1. Asking questions and designing scientific inquiry	790	24.1	3.07	0.83
2. Interpreting data and evidence scientifically	1,276	38.9	3.11	0.80
3. Explaining phenomena scientifically	859	26.2	3.08	0.78
4. Collaborating in a small group	511	15.6	2.92	0.91
Traditional teaching in physics				
5. Listening	1,360	41.6	3.05	0.82
6. Writing	518	15.8	2.90	0.83
7. Calculating	350	10.7	3.14	0.74
Chile				
	f	%	Level of situational interest (1-4)	Std. Deviation
Scientific practices situations				
1. Asking questions and designing scientific inquiry	472	40.8	3.02	0.95
2. Interpreting data and evidence scientifically	329	28.4	3.11	0.91
3. Explaining phenomena scientifically	357	30.8	3.20	0.83
4. Collaborating in a small group	255	13.1	3.24	0.85
Traditional teaching in physics				
5. Listening	591	36.1	2.97	0.97
6. Writing	340	20.8	3.24	0.83
7. Calculating	91	5.6	3.03	1.02

Table 3. Estimates for predictors of situational interest in Helsinki and Chile (Santiago & Viña del Mar).

Predictors	Estimates Helsinki	Estimates Chile
(Intercept)	1.83***	2.77***
Asking questions and designing scientific inquiry	0.04	0.09
Interpreting data and evidence scientifically	0.04*	0.14*
Explaining phenomena scientifically	0.19**	0.20***
Collaborating in a small group	-0.16**	0.12
Listening	-0.10*	-0.08
Writing	-0.15**	0.17**
Calculating	0.04	0.01
Being female	-0.07	0.26**
Interest in science studies and careers	0.37***	0.42***
<i>Random Effects</i>		
σ^2	0.35	0.59
τ_{00}	0.24	0.23
ICC	0.41	0.28
<i>N</i>	106	138
Observations (<i>N</i>)	1717	1767
Marginal R^2 /Conditional R^2	0.11/0.47	0.103/0.36

*** $p < .001$, ** $p < .01$, * $p < .05$.

Results

We refer first to results from responses to the questionnaire regarding students' personal interest in science and science-related careers and gender differences. Table 1 presents the means reflecting personal interest in science studies and careers. These were high both in Finland (between 3.0 and 3.4) and in Chile (between 2.4 and 3.0) on a scale of 1–4. In Chile, there were no gender differences, but in Helsinki, male students evaluated their interest higher than female students.

In response to research questions 1 and 2, the learning experiences and situational interest that students reported as having during their physics lessons are presented in Table 2. The table indicates the reported frequency of such experiences and level of situational interest elicited during each activity in Finish and Chilean classrooms. The total number of different activities is higher than the number of responses in both locations, because students could be engaged in different activities simultaneously. Students in Helsinki reported more frequently *listening* and then *interpreting data*, while in Chile they reported mostly *listening* and then *questioning* and *planning investigations*. In Finland, situational interest was highest while *calculating*, second highest while *interpreting data* and third highest while *asking questions and planning investigations*. In Chile, situational interest was highest while *writing*, second highest while *collaborating* and third highest while *explaining phenomena scientifically*.

Responding to research question 3, Table 3 illustrates how teaching/learning activities, student gender and student personal interest in science studies and careers predict situational interest in physics learning. The most powerful predictor in both countries was *interest in science studies and careers*. In both Helsinki and Chilean cities, student *explaining phenomena scientifically* or *interpreting data and evidence scientifically* also predicted situational interest. Situations in which students were *writing* predicted situational interest as well. In Helsinki, *collaboration*, *writing* and *listening* were negative predictors of situational interest. Female students experienced higher situational interest in science

than male students in Chile, but not in Helsinki. Intraclass correlation indexes indicated that in both countries, level 2 (student level) explains an important part of the variance of the dependent variable, which is higher than 20%. Both countries reported high conditional R^2 (Helsinki = 0.47, Chile = 0.36), which measures the variance accounted for by the fixed and random effects combined.

Discussion, conclusions and limitations of the study

In order to examine the association between student reported situational interest and types of learning activities, such as scientific practices and student collaboration, physics teaching modules with a strong emphasis on activities, were designed in Finland and Chile according to the relevant curricula in both countries. Our main aim was to bring out situations or types of learning activities that students report as occurring during lessons, and that correlate with situational interest, despite differences in educational contexts, curricula and teaching modules. The design of the teaching modules included activities emphasised in both countries' curricula and also known based on research to trigger or maintain situational interest, such as the use of scientific practices and working collaboratively. However, it is not possible to argue based on the data that a specific activity 'triggers situational interest' or 'maintains situational interest' (Hidi, 2006). We can argue based on the data that something is associated with situational interest.

As shown in Table 2, both the content and implementation of the teaching modules during the physics lessons proved to work well as far as their purposes. Thus, 63% of students in Finnish lessons and 79% in Chilean ones reported being engaged in scientific practices that required, for example, asking questions, designing scientific inquiry, interpreting data and providing evidence scientifically. When working with scientific practices, students in both locations rated their situational interest on average over 3 (scale of 1–4). Student collaborative work during lessons occurred in 16% of all situations in Finland and 13% in Chile, however, for Chilean students these situations were more interesting than the listening situations, compared to Finnish students. Engagement in calculations was also associated with situational interest, especially in Finland, which accords with previous research (Inkinen et al., 2020). Engagement in writing activities in Chile was associated with interest because writing was part of an inquiry activity in the teaching module, requiring students to seek information from the internet.

The findings in Table 3, offer a holistic view of the activities occurring in the physics classrooms and how, in both country locations, they predicted situational interest in physics learning. The predictors of situational interest, calculated by multilevel regression analysis, enabled comparison of the strength of different predictors. Even though the regression models in Table 3 supported the findings presented in Table 2, the models confirmed that the use of scientific practices are associated with situational interest more than with listening or calculating. Although, as explained above, Chilean students did report high levels of situational interest when they were writing, due to the nature of the task requiring this.

Activities in which students asked questions, designed scientific inquiry or conducted inquiry did not predict students' situational interest as had been expected, especially in Helsinki. But, activities in which students interpreted data and evidence scientifically, or

in which students were able to analyse data, develop models, construct explanations and develop arguments did predict situational interest in both locations. This is in line with findings of Krajcik and Blumenfeld (2006, p. 318), indicating that inquiry-based or project-based curricula support the development of situational interest if it includes real and meaningful topics that are important to students, as was the case of modules in both countries. In turn, scientific practices that better predicted situational interest in both locations were those in which students were able to explain phenomena scientifically or engage in activities requiring them to use knowledge, models or solve problems. This is in line with Renninger et al. (2015)'s conclusion that generating and seeking answers to questions better supports the development of interest compared to just receiving information from a teacher. Consequently, the use scientific practices are associated with situational interest in physics learning in both contexts. Even though this research topic is understudied, some studies have discussed the positive effects of scientific practices and students' experiences in science classes. For example, Grabau and Ma (2017) reported in a study focusing on 4,456 U.S. students that modelling was associated with personal valuing of science. Previous research has also revealed that scientific practices are associated with student situational engagement (Inkinen et al., 2020; Grabau & Ma, 2017).

Contextualising, as highlighted in the introduction to the modules, is important for the development of interest compared to only hands-on activities (Kanter & Konstantopoulos, 2010; Swarat et al. 2012). This explains why estimates related to scientific practices were higher in Chile than in Finland. In Chile, contextualisation focused on inquiries conducted in the context of life science (Bennett et al., 2016).

The regression equations indicate that student collaboration as such did not predict situational interest. In fact, collaboration was not statistically significant in the Chilean model and was a statistically significant negative predictor in Finland. This finding differs from results the study by Singh et al. (2002). However, their conclusions were based on pre- and post-test types of questionnaires, which do not capture interest in a real situation. They also did not control for other possible variables in their analysis.

Our analysis of scientific practices and collaboration and their influence over the development of situational interest has contributed to lessen the research gap found by Potvin and Hasni (2014)'s review of studies examining the relationship between science classroom activities and development of students' situational interest. Our study, supports the importance of teachers' role in the planning of learning activities, which include scientific practices not just those, which are based on listening, writing and calculating. Moreover, it is also important to stress contextualisation and design of activities relevant to students, such as those in the teaching modules used in our studies. As highlighted by Habig et al. (2018), enacting professional contexts, or contexts in which students work in a way similar to scientists, supports the development of situational interest. In other words, school science practices need to represent real scientific practices better (Anderson, 2007; EU, 2004; Tytler, 2014).

Regarding male/female differences in personal interest in science, male students in the Helsinki schools manifested a higher overall interest in science studies and careers than female students, similar finding to that in surveys measuring female and male students' interest in physics (Osborne et al., 2003). On the other hand, in Chile, no gender

difference was observed. Average situational interest was equal among male and female students in the Helsinki schools, but higher among female students in the Chilean schools than for their male peers (Aschbacher et al., 2010). One aim of the study was to investigate students, who have or do not have an interest in science studies and careers, situational interest. Interest in science studies or careers is linked to personal types of interest (Schiefele, 1999). According to the multilevel regression (Table 3), there is a strong link between personal and situational types of interest in both locations. Students who develop an interest in science studies and careers are also interested in studying science in various situations. Therefore, the role of the physics teacher in introducing careers in science and in how scientists work is important in triggering situational interest. Similar findings were noted in research by Rotgans and Schmidt (2018) and by Habig et al. (2018). Given this association, teacher efforts to stimulate in their students a personal interest in science and technology career options, might also stimulate situational interest in school science learning (Hazari et al., 2010; Knag et al., 2019).

Limitations

Although authors (Inkinen et al., 2019; Inkinen et al., 2020; Tuominen-Soini & Salmela-Aro, 2014) had experience with the use of ESM, the study had several limitations. Given its nature, requiring teacher acceptance and involvement in the use of the teaching modules, the sample could only be a convenience one, meaning that results cannot be generalised to populations and physics teaching in both countries. This limitation seems to have been partially overcome given similarities in some of the results, especially those referring to how the use of scientific practices in the lessons served to predict student situational interest. Another limitation of the study was that key evidence regarding the use of scientific practices was provided only by student reports in both country contexts and students might not have adequately interpreted the meaning of the concepts involved. However, to some extent, this limitation was lessened through prior explanation of the study to teachers and students. In both contexts, teachers provided students with information regarding the focus of the lessons and alerted them about the scientific practices in which they would be engaging. Although cultural differences could have influenced how the meaning of practices was interpreted by students, this was not observed in any of the two contexts. In the case of Chile, pre-experiment trials were held to verify how a different group of students understood the concepts and managed the smartphone instrument. In turn, as indicated above Finnish main researchers had experience with the system (Inkinen et al., 2019; Inkinen et al., 2020) and were able to prepare participating teachers accordingly.

The conditions in which students engage in scientific practice learning in relatively large classrooms are more complex from the point of view of management than traditional teaching and learning situations. Moreover, while practices follow a rational order, students may be at different phases of their classroom learning, or engaged in multiple practices at the same time, making teacher scaffolding a challenging task. These conditions could have influenced student responses in at least two ways. First, given that students might be involved in several practices at the time that they were asked to react to what was going on in the ESM survey, it is difficult to know which practice had greater influence over the reported level of engagement. Second, the same practice

might elicit a different level of interest, depending on whether it was conducted in the middle of the lesson or at the end, just before the break between the lessons.

Finally, another possible limitation would be the disruption of student learning and engagement three times during each science lessons when the smartphone beeped and requested information. However, we visited the schools during and after the data collection, and both teachers and students reported that while learning was somewhat disrupted at the beginning of data collection, this did not occur later. Also, as the ESM instrument repeated the same questions throughout the data collection, students became familiar with them. After a couple of collection situations, responding took less than two minutes. Some technical problems, such as low phone charges, occurred with the data collection but only for a minimal number of students.

Future work

While the ESM questionnaire is rather long and includes multiple-choice questions to facilitate self-reported data collection, it still does not provide a complete picture of ongoing teaching/learning activities or how adequately these are reflected in questionnaire items. Therefore, future research on situational classroom interest could profit from the use of video recordings or detailed lesson observation informing about the teaching/learning activities taking place and their context.

The scientific practices described in the ESM survey instrument were reduced to three categories in the linear regression models: asking questions and designing scientific inquiry, interpreting data and evidence scientifically, and explaining phenomena scientifically. This was done for two reasons. First, the frequency of single scientific practices tended to be small; consequently, combining the data provided better statistics. Second, some of the practices in the ESM questionnaire were similar to each other, such as 'planning investigations' and 'conducting investigations', 'developing models' and 'constructing explanations', as well as 'using models' and 'solving problems'. Therefore, in order to maintain the diversity of these variables in a possible future study, it would be useful to take more time to prepare students for a better understanding of the meaning of each scientific practice. In addition, the data collection time might be longer in order to report in more detail changes in interest levels regarding the different scientific practices. This might also facilitate the understanding of why different scientific practices increase or decrease students' interest. Future studies might also focus on just a couple of key specific scientific practices.

Curriculum changes have led physics instruction to place more emphasis on scientific practices. While the study discussed in this article provides promising results regarding relations between scientific practices and students' situational interest if learning is carefully contextualised, research with larger samples might provide better evidence about this association. Situational interest is important for several reasons among which is its association with student learning processes and outcomes (Finn & Zimmer, 2012, p. 98). But also, students who are stimulated to engage in science learning in one context, are also likely to look out for situationally engaging experiences in other contexts (Marks, 2000).

Results of this study, carried out in two different country locations, support the view that it is possible to use certain type of teaching/learning procedures involving student

engagement in scientific practices and thereby generating situational interest and learning. Use of such practices in science classrooms could be researched in other country contexts using different curricula in order to learn more about how education context and curricula influence the development of interest.

If future results support the findings of the study we have described, then teacher education and teacher professional development activities should include references to the importance of scientific practices in science learning and how these may influence interest in science and engineering careers. This type of knowledge is equally important for designers of learning environments and materials.

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Appendix 1. Example of the Helsinki module activity.

The following description is an example of an activity of the Helsinki teaching module. The description is a narrative, made based on a video, captured in a classroom. The teacher begins the lesson by introducing the topic of the lesson: “We will look at different movements, the change in movement, and the reasons behind the change. We will design experiments, models, representing movement, and discuss on models. ” ... “In order to understand the driving question, let’s look at the drop of coffee filters. I have one filter in one hand and two nested filters in the other hand. What do you think, how do filters fall? Do they fall at the same time? Look closely at what is happening. “ ... Based on the teacher demonstration, it is found that a heavier object ($2m$) hits the ground first. The teacher continues the demonstration by doubling the masses of falling objects. In the first demonstration: mass of the first falling object was m – mass of the second falling object $2m$; the following demonstrations: $2-4m$; $4-8m$; $8-16m$; $16-32m$ were done. ... The finding is surprising to students. In an experiments, $8-16m$; $16-32m$, the drops are very similar. Students are asked to summarise their findings in pairs and then combine the summaries through combining two pairs. ... Finally, a whole group discussion is organised. The teacher says that this demonstration was the anchoring phenomenon of the upcoming study period, which introduces the students to the theme of the five lessons of the course. A specific driving question is formulated: Why do different objects take different times to fall when they are dropped from the same height. (What is the motion of a falling object like?)

The teacher guides the student again to pairs or three student group and asks them to draw up research questions on the basis of which the phenomenon can be studied and an answer to the driving question obtained. Questions were asked to write to an online learning environment.

The teacher support students working in pairs and asks questions, such as, “Is it clear from the question what you intend to measure or observe? How should your question be changed so that everyone knows what you are going to measure?”

The teacher invites students back and asked students to classify the questions, posed in the learning environment in a meaningful way. The teacher says, “After you have classified the questions, your group will introduce them to the other group in order to discuss and compare the classification of other group. Make a common classification that you present to the whole class.” The teacher asks students to choose questions that can be used to find the answer to the driving question . . .

The teacher says that next we start to study the anchoring phenomenon based on the questions. First, a question or questions are selected to help investigate the falling motion (e.g. in what situation does the velocity of the falling object not change? What is the motion of the falling object then? (students’ questions)). The reasons for the change in movement was told to be examined later.

Next, the phenomenon was examined on the basis of movement-related questions. Students begin to design research in the direction of research questions in a small group. The teacher visited the groups and guides the use of ultrasound sensor. As students go further in measurement and modeling activities, the teacher supported students working by asking questions, such as “What is the evidence behind the claim? Does the material support the claim?”

At the beginning of the next lesson, the group presents the results to another group. After the presentations, a joint discussion takes place, concluding that the movements can be grouped into two groups: a movement with constant velocity and movements in which the velocity changes. The students introduced their verbal and graphic patterns that described the studies movements. Under the guidance of the teacher, mathematical models describing the movements are also built and the use of the models in solving various problems is practiced.

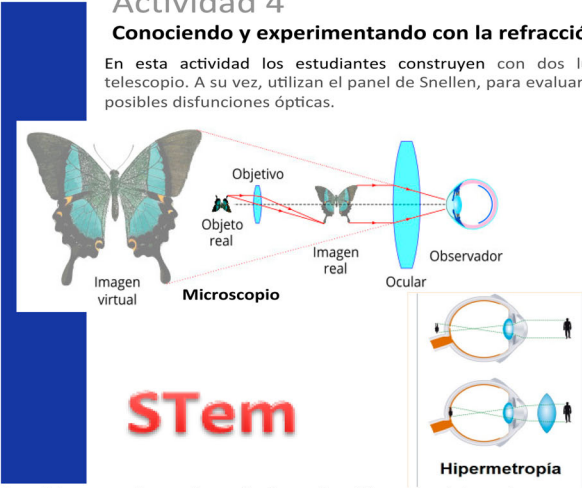
Appendix 2. Example of a teaching module activity: Chile.

Students carry out a set of activities that involve building a microscope and telescope using two magnifying glasses. They also use a Snellen panel to assess their visual sharpness and detect possible optical malfunctions. As shown in the figure below students plan and construct a model of microscope and telescope, analyse data and carry out mathematical calculations and interpretations collaboratively, building explanations and solutions based on their own vision evidence. STEM subjects involved are physics, biology, technology and mathematics.

Actividad 4

Conociendo y experimentando con la refracción de luz

En esta actividad los estudiantes construyen con dos lupas un microscopio y un telescopio. A su vez, utilizan el panel de Snellen, para evaluar su agudeza visual y detectar posibles disfunciones ópticas.



STem

E	1	20/200
F P	2	20/100
T O Z	3	20/70
L P E D	4	20/50
P E C F D	5	20/40
E D F C Z P	6	20/30
F E L O P Z D	7	20/25
D E F F O T E C	8	20/20
L E F O D P O T	9	
P D F L T O D O	10	
P E R O L O T T E	11	

- Analizan datos, con ellos realizan cálculos matemáticos y los interpretan
- Planifican y construyen un modelo de microscopio, y telescopio
- Construye explicaciones y soluciones en base a evidencia de su propia visión