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Students' attitudes towards climate change and their science career aspirations as predictors of situational motivation and knowledge

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ABSTRACT

The importance of climate-related education has been recognised, but little is known about what motivates students to learn about climate change. This study examines situational motivation in the context of a climate education module in an upper secondary school that emphasises project-based learning. We investigate variation in student motivation across activities, and the extent to which this is predicted by their attitudes to climate change and aspirations to pursue a career in science. We further assess the impact of these attitudes on their knowledge about climate change. Applying momentary assessment, we collected data on 2228 situations reported by 204 students (aged 16 years). The results show that science career aspirations affect motivation and climate change knowledge. Additionally, climate change attitudes influence motivation. Our findings highlight gender differences in attitudes towards and knowledge about climate change. They further imply that a project-based learning approach would be beneficial in the development of climate education modules.

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KEYWORDS
Climate education; situational motivation; ecological momentary assessment; multilevel modelling

Introduction

An understanding of climate change and its mitigation is an essential value in the national curriculum of Finland (Finnish National Agency for Education 2019a). According to the report of the Finnish National Agency for Education (2019b), both teachers and students believe climate change should be discussed in schools in a multidisciplinary, motivating and encouraging way, given the links with students' everyday lives. However, pedagogical approaches that motivate students to learn about adapting to or mitigating climate change remain unidentified (Favier et al. 2021; Monroe et al. 2019; Stratton et al. 2015). Although its significance is frequently highlighted in educational

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research, there is a lack of studies on the implementation of climate education aimed at motivating students to study climate-related issues. Research has identified its potential to enhance both knowledge and participation among young people, but it has additionally emphasised the need to develop and adopt more innovative, relevant and applicable educational methodologies (Muccione, Ewen, and Vaghefi 2025).

Our aim in the current study is to shed light on situational motivation among upper secondary students engaged in the climate education module by applying situated expectancy-value theory (SEVT; Eccles and Wigfield 2020). The perspectives of both situational motivation and climate education are relatively recent additions to the research field. In the current study, situational motivation is assessed by asking students to report their levels of interest, competence beliefs, perceived task difficulty, anxiety, and effort exertion across different learning situations.

In our previous research, we found that students' situational motivation in climate education varies across learning activities and between students; for example, generating ideas was associated with higher levels of motivation (Ronkainen et al. 2025). Building upon this foundation, this study explores students' attitudes to and knowledge about climate change, as well as their aspirations regarding careers in science. Previously, Dijkstra and Goedhart (2012) studied these connections and identified a correlation between attitudes towards science and environmental issues. Consequently, they recommended that greater emphasis should be placed on the attitudes of students taking science courses in secondary schools, as well as on the activities that promote such attitudes. Our study contributes towards closing this research gap.

Students' situational motivation

The current study is based on SEVT, which explains how students' success expectancies and task values relate to their academic performance and the choices they make regarding their studies (Eccles et al. 1983; Eccles and Wigfield 2020). Within this framework, motivation derives from students' perceptions of the value of assigned tasks and how they can succeed in them. Motivation is perceived as contextual, in that the learning situation influences the decisions students make (Eccles and Wigfield 2020). In addition, students are influenced in their study decisions by prior experiences, their identity and prevailing cultural values (Wigfield and Eccles 2024). In the present study, we examine how situational motivation develops in climate-related education, paying particular attention to how learning experiences related to sustainable development and careers in science may cultivate students' interest and enhance their motivation.

Subjective task values concern the importance and usefulness of study topics as perceived by students. A task's value could be considered three-dimensional: the enjoyment it provides (interest value); the potential benefits it offers, particularly for future career prospects (utility value); and its identity-based significance in shaping a sense of self (attainment value) (Eccles et al. 1983; Eccles and Wigfield 2020; Eccles 2005). In addition to values, students have expectations regarding their academic success and beliefs about their ability to complete classroom assignments effectively.

Alongside the positive values they adopt, students may encounter negative costs when choosing and carrying out academic tasks. Completing the task may require too much effort, take time and resources away from more meaningful activities, or cause emotional distress (Eccles et al. 1983). Additionally, previous studies report a correlation between effort and motivation. Findings from these studies demonstrate that highly motivated students tend to view effort as a positive factor, whereas the less motivated perceive it as negative (Dietrich et al. 2017; Malmberg et al. 2013). Consequently, effort and motivation are intertwined, functioning as a double-edged sword: effort enhances motivation when it is high and reduces motivation when it is low. Therefore, effort should be interpreted alongside motivational variables rather than as an independent variable. In this study, the focus is specifically on interest value within the broader framework of task values. Situational success expectations are operationalised by measuring students' competence beliefs and perceived task difficulty. Feelings of anxiety are examined to measure emotional cost. Additionally, the variables are discussed in relation to perceived effort to determine how effort varies with motivation.

It has been shown that motivation varies both from student to student and from learning situation to learning situation (Dietrich et al. 2017). Various studies report that situational motivation is influenced by a combination of factors: the broader learning context, the immediate learning situation, and its timing with other learning processes (Törmänen et al. 2025). Our aim in this study is to capture students' situational motivation by means of ecological momentary assessment (see Hektner, Schmidt, and Csikszentmihalyi 2007). We will consider student motivation on two distinct levels: the variation across different situations and learning activities, and the differences among students. The use of momentary data allows for analysis on both the student and the situational level (Hormuth 1986). Motivation is therefore understood as a dynamic phenomenon that shifts according to the learning activities at hand.

Climate change and science-related attitudes and knowledge

The Attitudes towards Climate Change and Science Instrument (ACSI; Dijkstra and Goedhart 2012) measures how students feel towards science, scientists, climate change and the environment. The instrument consists of multiple questionnaires, each of which measures different dimensions. It is based on the conception that students who are environmentally conscious exhibit a heightened interest in the subject matter and demonstrate environmentally responsible behaviour (Kuhlemeier, van den Bergh, and Lagerweij 1999). The attitudes under scrutiny concern the beliefs and reactions a specific topic elicits (Dijkstra and Goedhart 2012). The focus here is on the beliefs that students hold regarding climate change and the career of a scientist, as well as the behaviours they engender. Attitudes are influenced by various factors such as gender, the learning environment, the teacher and perceived task difficulty (Osborne, Simon, and Collins 2003).

Regarding climate knowledge, ACSI measures multidimensional understanding of climate change, incorporating not only scientific facts but social and ethical dimensions and societal impacts (Dijkstra and Goedhart 2012). Assessing both knowledge and attitudes facilitates further examination of whether these attitudes are supported by a solid understanding. The literature on the relationship between attitudes towards subjects studied and learning outcomes is inconclusive. Previous research in the field of science education has revealed a lack of correlation, moderate correlation and a consistent relationship between positive attitudes towards science and competence (Osborne, Simon, and Collins 2003). Consequently, the reliability of this relationship has been called into question, given that findings have not been consistently replicated across studies. However, researchers have identified a relationship between educational attainment and concern about climate change, whereby individuals with higher levels of education tend to show greater concern (Hoekstra et al. 2024). In addition, studies have shown that concerned students perform well in knowledge tests (Harker-Schuch and Bugge-Henriksen 2013; Harrod and Rolland 2021).

Gender differences in science

According to SEVT, gender shapes motivation through intertwined factors such as early socialisation, the expectations of parents and prevailing cultural stereotypes, all of which guide students in their educational choices (Eccles et al. 1983). In the field of SEVT, researchers have expressed particular concern about the lower expectations and higher costs experienced by women studying in the sciences (Wigfield and Eccles 2024). In previous person-oriented studies, no gender differences have been found among Finnish lower secondary school students across different subject domains (Ronkainen et al. 2024), although boys showed a stronger orientation toward mathematics than girls in the final grade of lower secondary school (Chow and Salmela-Aro 2011).

Attitudes towards science-based career aspirations are influenced by many factors, including feelings about specific science subjects and science-related resources and support shaped by parental interest and encouragement (DeWitt and Archer 2015). Gender differences in orientation to science fields have additionally been the subject of extensive research, many studies having shown that women students are less interested in physics than their male counterparts (e.g. Hoffmann 2002; Renninger, Hidi, and Nieswandt 2015). One reason for this difference is the perception among women students that they have fewer opportunities than men to engage in science and a science career (Aschbacher, Li, and Roth 2010). Another reason is the lack of female role models in science and engineering, which affects not only their personal image but also their identity as a scientist (Settles, Jellison, and Pratt-Hyatt 2009).

However, such attitudes appear to be subject-specific within the natural sciences: the differences are small in chemistry, and women are more interested in biology than men are (Osborne, Simon, and Collins 2003). In the context of climate education, previous studies conducted in upper secondary schools report that both male and female students expressed positive attitudes towards studying climate change, but women expressed greater interest in its various aspects (Dijkstra and Goedhart 2011). Women have additionally been shown to report greater concern towards climate change than men (Harrod and Rolland 2021; McCright 2010).

Project-based learning in climate education

The challenge in teaching and learning about climate change is attributable to its multidisciplinary nature. It is necessary to understand various fields to comprehend climate related issues, design mitigation and adaptation solutions, and engage in climate-related actions on personal, local and societal levels (Favier et al. 2021). To address these multifaceted issues, it is recommended that pedagogy in climate education adopts a student-centred, participatory, inquiry-based approach (Monroe et al. 2019; Rousell and Cutter-Mackenzie-Knowles 2020), such as project-based learning (PBL; Kokotsaki, Menzies, and Wiggins 2016).

PBL is a situation-based approach to learning. Situational motivation in science learning is strongly shaped by both the content and the context in which it takes place (Törmänen et al. 2025). These factors influence students' immediate engagement and may either foster or impede their interest. Scientific content that is meaningfully connected to students' lives within an authentic learning environment enhances its perceived relevance and purpose, thereby increasing motivation (Järvelä and Renninger 2014). The main goals of this educational approach are to encourage students to work actively and collaboratively, and to use scientific and technical practices (Krajcik and Shin, 2014). These practices lead to the creation of concrete outputs, such as a final report. In PBL, students develop a guiding question and answer it using data, for example, by building models and generating and evaluating new ideas. In essence, students generate ideas, work with data, and read diverse source materials while working on their end project to answer the driving question. These steps are defined as learning activities in this study. Previous research has linked these specific activities, such as working with data and generating solutions, with enhanced student motivation (Dijkstra and Goedhart 2011; Inkinen et al. 2020; Ronkainen et al. 2025; Vilhunen et al. 2025).

The current study

Our aim is to determine the extent to which attitudes towards the urgency of climate change, aspirations towards a science career and different learning activities affect students' situational motivation. A further aim is to assess how these attitudes affect knowledge about climate change and whether there are gender differences in this respect. We examine climate models from the perspective of PBL and consider gender differences and engagement in studying, as recommended in earlier research (Baltikian, Karkkainen, and Kukkonen 2025). Figure 1 illustrates the conceptual model of the study with latent variables. Our methodological approach is Multilevel Structural Equation Modelling (MSEM), the aim of which is to obtain information about the phenomenon under study on different levels. The methodological framework allows for the examination of two key components, namely the dynamic variation of student motivation in different situations and the differences among students. This approach facilitates the examination of motivational disparities on the student level in diverse contexts, as well as the identification of distinct types of learners within the classroom environment.

The research questions are as follows:

RQ1: How do different learning activities predict students' situational motivation?

RQ2: How do science career aspirations predict students' situational motivation and climate change knowledge acquisition?

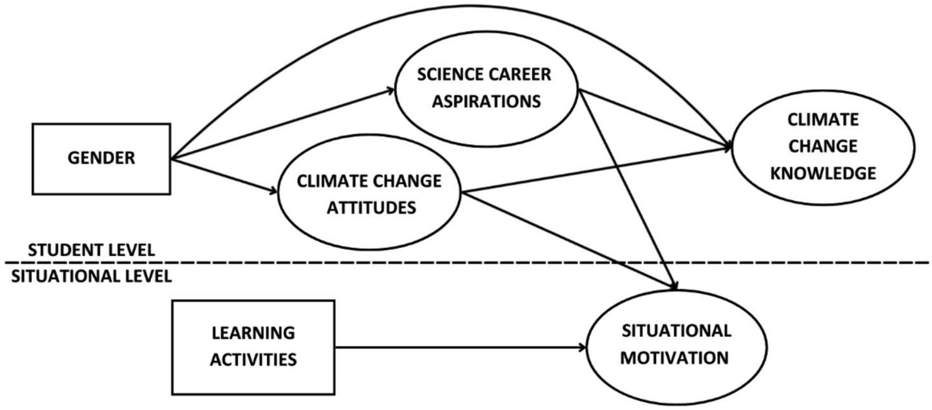

Figure 1. A conceptual model of the current study.

RQ3: How do attitudes towards climate change predict students' situational motivation and climate change knowledge acquisition?

RQ4: How does gender predict students' science career aspirations, and climate change attitudes and knowledge?

In addressing the RQ1, we hypothesise that different learning activities predict situational motivation. This hypothesis is based on findings from previous research indicating that student motivation varies at different learning moments and during different learning tasks (Dietrich et al. 2017; Ronkainen et al. 2025). We posit that activities related to PBL, namely those involving looking for information, generating ideas and working with data, are particularly motivating, compared to more traditional activities such as following the teacher's presentation and doing exercises. Generating ideas and working with data have been previously associated with higher student motivation (Dijkstra and Goedhart 2011; Inkinen et al. 2020; Ronkainen et al. 2025; Vilhunen et al. 2025).

For RQ2, we further hypothesise that science-focused aspirations predict higher situational motivation and higher climate change knowledge. It has been shown that students who have already developed a personal interest in the subject matter and place significant value on it are more likely to maintain their interest during a science course (Lavonen et al. 2021). Aspirations towards a science career have been identified as influencers of student motivation (Zhou and Shirazi 2025). According to SEVT, high interest predicts higher academic achievement (Eccles and Wigfield 2020).

With regard to the RQ3, we hypothesise that climate change attitudes predict higher situational motivation and climate change knowledge. Attitudes towards climate change are assessed by examining how seriously students perceive climate change and how concerned they are about it. We assume that students who take climate change seriously are more motivated to learn about the topic, as prior interest is generally associated with a greater willingness to engage with the subject (Lavonen et al. 2021). Previous research on the relationship between attitudes and knowledge has yielded mixed results, allowing for multiple possible hypotheses. Although some studies indicate a correlation between attitudes and knowledge, most findings appear to be incompatible with this hypothesis (Osborne, Simon, and Collins 2003). However, earlier studies have shown that students who are concerned about climate change tend to perform well on knowledge tests (Harker-Schuch and Bugge-Henriksen 2013). Therefore, we expect similar results in this study, namely that higher levels of climate change attitudes predict higher levels of climate change knowledge.

In terms of RQ4, we hypothesise that males will demonstrate a higher level of knowledge about climate change. Although previous research findings have indicated that females show more positive attitudes towards various aspects of climate change (Dijkstra and Goedhart 2011), this module was implemented within the subject of physics, a field in which males have traditionally performed better (Chow and Salmela-Aro 2011). Consequently, we hypothesise that men will exhibit a stronger tendency to pursue careers in science (Eccles and Wigfield 2020; Renninger, Hidi, and Nieswandt 2015). On the other hand, previous research has shown that female students tend to report higher levels of concern about climate change (Harrod and Rolland 2021); therefore, we expect female students to exhibit higher levels of climate change–related attitudes in this study.

Materials and methods

Context of the study

The climate education module examined in this study was developed during a period of long-term research collaboration between the research team and teachers. The module was implemented by four physics teachers at an upper secondary school in Helsinki, Finland, who actively participated in its co-design. During the research-practice partnership, both teachers and researchers worked as equal partners in the team, and as co-developers of instructional materials (Coburn and Penuel 2016). The module was implemented across three school years (2021–2023), each cycle being supported by structured meetings for planning and reflection. This study focuses on the most recent module implementation. The module focused on two central themes related to climate change: 'producing and using energy and materials' and 'the mitigation of climate change'. The overarching question guiding the module was: 'What actions can I and we take to mitigate global warming and contribute to the creation of a carbon-neutral society?'.

In the module, PBL was selected as the pedagogical framework, given its documented association with increased student engagement (Inkinen et al. 2020; Jorgenson, Stephens, and White 2019). In working on their projects, students engage in scientific and engineering practices aligned with the driving question, making sense of climate phenomena and designing solutions to climate-related challenges. This involves asking questions, recognising problems, seeking and evaluating information, generating ideas, and arguing for their feasibility. Concretely, students generate ideas, work with data, and read diverse source materials as they iteratively refine their projects to address the driving question. A more detailed description of the module can be found in the supplementary material and detailed descriptions of the lessons are provided in a previous study conducted as part of the research project (Neito et al. 2025).

Participants and procedure

The data collection took place in the autumn of 2023 and the spring of 2024 as part of the ClimComp (Learning of the competencies of effective climate change mitigation and adaptation in the education system) research project. The University of Helsinki Ethical Review Board found the study to be ethically acceptable (statement 44/2021). A total of 235 students participated in the module, of which 221 (94%) participated in the momentary data collection. Informed consent was obtained from the participants, and their guardians were informed of the study. The momentary data comprises 2228 situational responses from 204 students (52% females, mean age 16 years) in their first year of upper secondary studies. Some students had selected a science oriented programme in upper secondary school, which offers more science-related courses compared to the traditional line. Nine groups of students participated.

The module consisted of seven 90-minute lessons, the first and last being devoted to the longer questionnaires. The research group provided snacks and beverages for the students during these lessons. The module lasted approximately one month, involving one or two lessons per week. During the first lesson, the students downloaded the m-Path app (Mestdagh et al. 2023) onto their own mobile devices, and this was used to collect intensive momentary data. Students were reminded to complete the short questionnaire three times during a 90-minute lesson, and on average, they completed 10.96 situational questionnaires. Figure 2 presents the data collection process for the dataset used in this study. Additionally, the students completed a short questionnaire at the end of the lesson, with different items that do not concern this study. Thus, on lessons 2–6, students answered a total of 4 questionnaires. The intensive nature of the momentary data collection, which interrupts the teaching

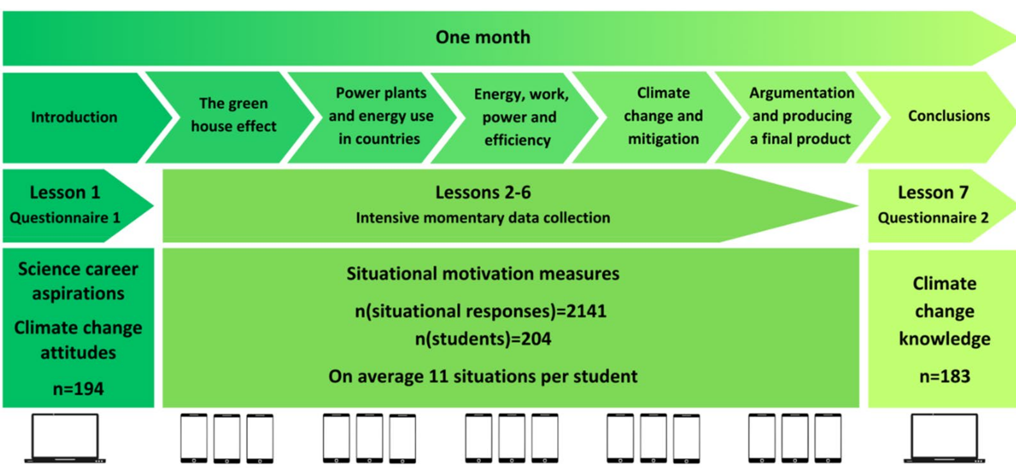

Figure 2. The study design.

process on multiple occasions, supports the recommendation that the survey should take no more than one minute to complete (Hektner, Schmidt, and Csikszentmihalyi 2007). Consequently, the measurement of each dimension was limited to one statement.

Measures

Situational motivation

Situational motivation was assessed on five questions based on SEVT (Eccles and Wigfield 2020). Each item assesses one dimension: interest ('Were you interested in what you were doing?'), competence belief ('Did you feel skilled at what you were doing?'), task difficulty ('Did you feel challenged by what you were doing?'), anxiety ('I feel anxious') and effort exertion ('How much effort were you putting into the task?'). The items were rated on a 5-point scale (1 = Not at all, 5 = Very much).

Learning activities

Learning activities were selected for the questionnaire based on the module design. They were formulated as follows: 'Working in a group or with a pair', 'Following the teacher's presentation', 'Doing exercises', 'Reading or looking for information', 'Generating ideas' and 'Working with a data or on a problem'. The question was of a multiple-choice nature, allowing for the selection of multiple options.

Attitudes towards the urgency of climate change

Attitudes to climate change were assessed on a six-question scale based on ACSI (Dijkstra and Goedhart 2012). All six items measured one dimension (e.g. 'People should care more about climate change'), rated on a 5-point scale (1 = Strongly disagree, 5 = Strongly agree). The mean values ranged from 2.02 to 4.48, with the highest mean for the item 'Climate change is a threat to the world' and the lowest mean for the item 'The seriousness of climate change has been exaggerated' (reversed). The full instruments with item-level mean scores are provided in the supplementary materials.

Attitudes towards a career in science

Science aspirations were assessed on a three-question scale based on ACSI (Dijkstra and Goedhart 2012). All three items measured one dimension (e.g. 'A job as a scientist would be interesting'), rated on a 5-point scale (1 = Strongly disagree, 5 = Strongly agree). The mean values ranged from 2.87 to 3.31, with the highest mean for 'A job as a scientist would be interesting' and the lowest mean for 'I would like to be a scientist after I leave school.'

Knowledge of climate change

Knowledge about climate change was measured using the Climate Change Knowledge Test, based on ACSI (Dijkstra and Goedhart 2012). The test included 12 items that were rated true, false or do not know. Each correct answer scored one point, the maximum number of points being 12. Item-level means ranged from 1.07 to 2.20, with the highest mean for 'There is a direct link between climate change and skin cancer' and the lowest means for 'Most of the current climate change is due to greenhouse gases generated by human activity,' 'Increased flooding and drought are some of the consequences of climate change,' and 'Because of climate change, the water in seas and oceans will expand.'

Student characteristics

Background information, such as gender and age, was collected in the pre-questionnaire. Gender was measured against the response options male, female, other and refuse to answer. The latter two options received a limited number of responses; therefore, further analysis was based on a binary male/female breakdown with dummy coding of the variable (0 = Male, 1 = Female).

Analytical strategy

MSEM was the analytical strategy chosen for the study. All variables were incorporated into a unified two-level model. The model's situational-level variables were controlled for the relationship between learning activities and situational motivation. A cross-level analysis was conducted to ascertain the relationship between climate-related attitudes, science aspirations and situational motivation. The model further specified a student-level link between gender and attitudes, aspirations, and knowledge about climate change. The relationship linking attitudes, aspirations and knowledge was examined, allowing attitudes and aspirations to correlate. We used various fit indices to assess the model's adequacy, applying the conventional cutoff values for an acceptable fit, namely CFI and TLI ≥ 0.90, SRMR ≤ 0.05, and RMSEA ≤ 0.10 (Hu and Bentler 1999). We considered the size of the data and the complexity of the multilevel model (Hooper, Coughlan, and Mullen 2008) when interpreting the findings.

From the total of 221 participants, gender data were missing from 11 (5%), test scores from 22 (10%), climate attitudes from 2 (1%), science aspirations from 3 (1%) and momentary responses from 17 (8%). We processed the missing data using the full information maximum likelihood method (FIML) with robust standard errors (MLR estimator). We conducted the analyses using MPlus software version 8.8 (Muthén and Muthén 1998). Mplus syntax is available in the supplementary material.

Methodological reflection and limitations

The data collection proceeded without technical issues, the teachers being familiar with the procedures. Based on prior experience, we decided that it was feasible to gather three ESM measurements per 90-minute lesson without causing fatigue, with prompts delivered at consistent intervals. However, given that momentary data collection is intensive and burdensome, we used only one item per dimension for the motivation measures, thereby preventing their full validation. Climate change related indicators were drawn from a validated set, but for the motivational variables, it was not possible to measure all aspects of SEVT within the short questionnaire. To allow for rapid responses, we included only the interest value from task value, given that it reflects situational value more than attainment or utility value, which are longer-term constructs. Similarly, we focused solely on the emotional cost; future research could incorporate other cost dimensions to yield a more comprehensive understanding of the relationships among the motivational variables. A participation rate of 94 per cent further supported the reliability of the study.

The data collection was intensive, requiring close and long-term collaboration with teachers. The module was carefully designed, together with the teachers, as the product of years of work. As a result, data were collected in a single high-performing upper secondary school to which admission required an average GPA of approximately 8.6. The study's limitations stem from its execution within a single school and within a single module. Consequently, the study's findings are limited in terms of generalizability due to the relatively uniform sample of students. However, they also facilitate intensive collaboration and careful planning of the module with teachers.

Some participants enrolled on a selective natural-science programme, which may have increased their interest and competence in climate-related topics. Earlier research has shown that students in science programmes are generally more motivated and competent in modules focused on climate education (Ronkainen et al. 2025), which limits the generalisability of the results. This data set does not enable distinctions to be made between students of natural science and those in general programmes. It would be interesting to see if the former are more interested in working as scientists.

Based on our close cooperation and planning, we expected the lessons to be consistent. The learning activity measurements are based on student evaluations. To obtain more accurate results, a researcher would have needed to observe the lessons, or the teacher's reports would have needed to be used to verify the assessment of classroom situations. Classroom dynamics are shaped by multiple factors, such as relationships among students and between students and the teacher, teacher authority, task design, and instructional practices. These factors were not explicitly accounted for in the evaluation of the results. Although teachers received training on how to implement the module and student groups were randomly assigned, unmeasured influences related to classroom interactions and the role of teacher may still have affected students' motivation, interest and knowledge. These variables were not measured or controlled in the analyses, preventing the detection and discussion of their amounts.

The examined model was constructed in a way that science career aspirations and climate change attitudes were measured only in the pre-survey, and climate change knowledge only in the post-survey. The model could also be constructed differently if the same statements were collected in both the pre- and post-surveys. The direction of the predictors was also taken into consideration. In many studies, aspirations have been predicted using motivation variables; however, in this study, an alternative approach was taken to examine the variables. Therefore, there are several different ways of constructing the model, and it would be both interesting and informative to examine the variables using different settings.

Results

Descriptive statistics

The descriptive statistics yielded correlations ranging from insignificant to moderate at both the situational and student levels. The highest correlation was found between

Table 1. Between-person correlation matrix and descriptive results.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Interest (M)	–								
2. Competence belief (M)	0.37**	–							
3. Task difficulty (M)	0.11*	−0.0	–						
4. Effort exertion (M)	0.24**	0.15*	0.20**	–					
5. Anxiety (M)	−0.08	−0.16*	0.18**	0.02	–				
6. Climate attitudes (PRE)	0.15**	0.09*	0.00	0.03	0.04	–			
7. Science career aspirations (PRE)	0.28**	0.26**	−0.11*	0.05	0.01	0.24**	–		
8. Climate change knowledge (POST)	0.36*	0.46**	−0.16	0.05	−0.19	0.12	0.38*	–	
9. Gender (PRE)	−0.04	−0.05*	−0.01	0.02	0.06*	0.13**	0.02	−0.22*	–
n	2228	2228	2228	2228	2238	219	218	199	211
mean	2.95	2.84	2.43	2.56	2.16	3.92	3.14	7.68	0.53
variance	1.23	1.26	1.26	1.24	1.48	0.45	0.98	3.96	0.25
intraclass correlations	0.42	0.38	0.23	0.29	0.50				
skewness	−0.08	0.00	0.48	0.30	0.82	−0.46	−0.22	−0.62	−0.12
kurtosis	−0.61	−0.72	−0.45	−0.57	−0.34	−0.06	−0.28	1.10	−1.99

M: momentary item; PRE: pre-questionnaire item; POST: post-questionnaire item.
** $p < 0.001$, * $p < 0.05$.

knowledge of climate change and belief in competence. Table 1 reports the descriptive statistics that include between- -person correlations. The within-person correlations for situational variables can be found in the supplementary material. The intraclass correlation coefficients ranged from 0.23 to 0.50, indicating that most of the variation in student motivation occurred on the situational rather than the student level. Variability in perceived task difficulty exhibited the greatest variation between situations (0.23), whereas experienced anxiety demonstrated comparable variability both among students and between situations (0.50).

A multilevel regression model was estimated using MLR estimation. The chi-square test was statistically significant, $\chi^2(5, N = 1743) = 29.47$, $p < 0.001$, which is common with large sample sizes. Other fit indices indicated a good-to-excellent fit: CFI = 0.982; RMSEA = 0.048; $SRMR_{(within)}$=0.001; $SRMR_{(between)}$ = 0.050. The TLI value was relatively low (TLI = 0.732), which is not uncommon in multilevel models with a small number of degrees of freedom, given the sensitivity of TLI to model complexity (Hooper, Coughlan, and Mullen 2008). Overall, the model fit was considered good.

Learning activities as predictors of situational motivation

The model examined how different learning activities predict situational motivation at the within-person level. Table 2 shows all of the regression coefficients. Working in a group or with a partner positively predicted effort exertion ($p < 0.01$), implying that it requires effort to work in pairs. Following a teacher's presentation negatively predicted perceived task difficulty ($p < 0.01$) and effort exertion ($p < 0.001$), indicating that it is perceived as easy and not requiring effort. Doing exercises positively

Table 2. Regression coefficients to describe learning activities as predictors of situational motivation.

		Group work	Teacher presentation	Doing exercises	Reading	Generating ideas	Working with data
Interest	B	0.05	0.02	−0.08	0.04	0.17	0.39**
	SE	0.06	0.06	0.05	0.09	0.10	0.12
Competence belief	B	0.04	−0.04	−0.08	−0.02	0.20*	0.07
	SE	0.07	0.07	0.06	0.08	0.10	0.15
Task difficulty	B	0.10	−0.20**	0.17*	0.10	−0.02	0.16
	SE	0.06	0.07	0.07	0.09	0.10	0.14
Anxiety	B	0.01	−0.01	0.12	−0.01	0.00	0.03
	SE	0.06	0.06	0.06	0.10	0.12	0.13
Effort exertion	B	0.27***	−0.29***	0.04	0.04	0.11	0.42**
	SE	0.06	0.06	0.07	0.09	0.11	0.14

***$p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

predicted perceived task difficulty ($p < 0.05$). Generating ideas positively predicted competence belief ($p < 0.05$), highlighting the fact that students feel they are good at it. Working with data or on a problem positively predicted interest ($p < 0.01$) and effort exertion ($p < 0.01$). See the supplementary material for visualisations of all the significant connections. Each level (the results of the within-, between-, and cross-level analyses) is visualized separately in the supplementary materials for clarity.

Science career aspirations as predictor of situational motivation and climate change knowledge

On the cross-level, the findings indicate that positive science career aspirations are associated with heightened situational interest ($p < 0.01$) and competence belief ($p < 0.001$) among students on the climate education module. The model indicates a negative relationship between career aspirations and perceived task difficulty ($p < 0.01$). Consequently, students who are enthusiastic about pursuing a career in science are more likely to be interested in studying, to feel more competent, and not to feel challenged during the module. The same model additionally analysed relationships on the student level that connected aspirations concerning careers in science and knowledge about climate change. Science aspirations positively predicted knowledge about climate change ($p < 0.05$), which indicates that interest in pursuing a scientific career is associated with a higher level of knowledge about climate change. Table 3 shows the regression coefficients.

Relationships between climate change attitudes, situational motivation and climate change knowledge

The cross-level findings reveal a positive relationship between attitudes to climate change and situational interest ($p < 0.001$), which implies that heightened concern about climate change has a significant impact on student interest in the subject. In the between-level, there was no statistically significant relationship between attitudes towards and knowledge about climate change. Table 4 shows the regression coefficients.

Table 3. Regression coefficients revealing career aspirations as predictors of situational motivation and climate change knowledge.

		Interest	Competence belief	Task difficulty	Anxiety	Effort exertion	Climate change knowledge
Science career aspirations	B	0.24**	0.27***	−0.12**	0.00	0.05	0.33*
	SE	0.06	0.06	0.05	0.07	0.06	0.14

***$p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Table 4. Regression coefficients revealing climate change attitudes as predictors of situational motivation and climate change knowledge.

		Interest	Competence belief	Task difficulty	Anxiety	Effort exertion	Climate change knowledge
Climate change attitudes	B	0.23***	0.09	0.05	0.07	0.05	0.30
	SE	0.08	0.08	0.08	0.11	0.08	0.26

***$p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Gender as a predictor of science aspirations and climate change attitudes and knowledge

Finally, the model examined how gender predicts science career aspirations and climate change variables. The findings indicate a statistically significant association linking gender with attitudes towards climate change ($r = 0.48$, SE = 0.09, $p < 0.001$) and knowledge about climate change ($r = 1.08$, SE = 0.30, $p < 0.001$). However, no such association was observed concerning science aspirations ($r = 0.03$, SE = 0.14, $p = 0.816$). Gender was dummy-coded (0 = male, 1 = female), the results implying that girls are more concerned about climate change than boys, whereas boys demonstrate a higher level of knowledge about the subject.

Discussion

There has been little research on pedagogical approaches aimed at motivating students to study climate change, which is a serious global issue. Previous research has been exploring ways of studying student motivation (Eccles and Wigfield 2020) and determining their attitudes toward climate change (Dijkstra and Goedhart 2012). We aimed to integrate these two theoretical lines and examine the impact of attitudes on motivation and competence. We used MSEM to ascertain the relationships connecting students' situational motivation, attitudes towards the urgency of climate change and aspirations for a career in science, as well as their knowledge of climate change. Our findings indicate that learning activities emphasising PBL, such as working with data and generating ideas, appear to enhance motivation in the climate education module. A closer look revealed differences in motivation and competence among the students, which were influenced by student characteristics.

Situational motivation varies across learning activities

In addressing RQ1, we assessed the extent to which learning activities predict students' motivation. Our results show that different learning tasks influence experiences of situational motivation. When it came to more traditional learning activities, it seemed that students found it easy to follow the teacher's presentation without requiring significant effort. Doing exercises in class was perceived as challenging. These activities are therefore more closely related to students' success expectations than to their values.

We expected activities related to PBL in particular to motivate students. The findings supported the results of previous research (Dijkstra and Goedhart 2011; Inkinen et al. 2020; Ronkainen et al. 2025; Vilhunen et al. 2025): generating ideas increased students' sense of competence, working with data boosted their interest, and they put effort into group work. In situations where students are permitted to engage actively, they appear to develop a sense of competence and interest. Given that climate change lacks a clear-cut solution, encouraging students to generate ideas without fear of making mistakes could foster curiosity and deepen engagement (Shin et al. 2019). The intraclass correlations revealed the greatest variability between situations as opposed to among students. The implication here is that motivation varied from moment to moment during the module, rather than remaining consistently high or low among certain students. If motivation varies depending on the situation rather than the student, even students who do not already have a high level of interest in the subject can be sparked to engage with it through interesting activities. PBL could therefore function as a motivating pedagogical approach for all students.

Science aspirations as pathways to climate knowledge

With regard to RQ2, we investigated the relationships linking science-related career aspirations, students' situational motivation and climate change knowledge. The results showed, that science career aspirations were associated with higher interest in the module. This result was consistent with the hypothesis based on previous research in that we assumed personal involvement in the topic would increase situational interest (Lavonen et al. 2021). Conversely, science-related career aspirations related positively to a belief in competence and negatively to perceived difficulty. These findings support those reported in previous studies demonstrating that interest, values and achievement expectations predict student perseverance in the science field (Rosenzweig et al. 2021). In addition, students aspiring to become scientists demonstrated a more profound understanding of climate change than those who were open to alternative career paths.

Students' climate change attitudes reflect situational motivation

For RQ3, our hypothesis further posited that climate change attitudes would similarly predict higher situational motivation. Indeed, climate change attitudes, reflecting concern towards climate change, heightened interest in the module. Therefore, the results show that climate change concern seems to increase interest in the subject, but does not predict effort or feelings of competence. When concern does not increase effort in studies, it would be interesting to investigate how the variables are related to pro-environmental behaviour. However, the relationship between climate-related attitudes and knowledge was not significant, implying that concerns alone do not predict students' understanding of climate change. This finding was contrary to our expectations, as previous research led us to assume that concern about climate change would predict higher levels of knowledge (Harker-Schuch and Bugge-Henriksen 2013). Previously, the relationship between attitudes and knowledge has been described as bidirectional, indicating a complex association (Osborne, Simon, and Collins 2003). The results of this study imply that while higher levels of attitudes and concern may enhance students' interest in the topic, they do not necessarily translate into greater effort or increased knowledge acquisition.

Men and women differ in terms of knowledge and attitudes

In RQ4, we examined gender differences in climate change attitudes, science career aspirations and climate change knowledge. In line with our expectations and findings from previous studies, we found that men exhibited more knowledge about climate change in comparison to women (Chow and Salmela-Aro 2011), whereas women expressed greater concern about it in comparison to men (Harrod and Rolland 2021). Thus, female students exhibit higher levels of climate change–related attitudes, whereas male students demonstrate higher levels of factual knowledge about the topic. Education should support women by promoting competence in their climate-related knowledge, since knowledge development is essential in terms of changing attitudes and strengthening commitment to mitigating climate change on the societal level (Harker-Schuch and Bugge-Henriksen 2013). Interestingly, and contrary to previous research findings, gender did not serve as a predictor of an inclination to pursue a career in science (Renninger, Hidi, and Nieswandt 2015). According to our findings, gender differences in career aspirations appear to have levelled out.

Educational implications and conclusions

Teachers in Finland have a high level of professional autonomy (Chung 2023), which provides them with both the freedom and the responsibility to shape how climate change is addressed in their classrooms. This autonomy provides educators with opportunities to take the lead in developing innovative practices. As our findings show, PBL offers a powerful and motivational approach to climate-related education. As reported in previous research, not only does it enhance student engagement, but it positively influences climate awareness and related actions (Istance and Oaniagua 2019). Therefore, integrating PBL methods into educational practices could foster meaningful learning experiences that empower students to take informed action to mitigate climate change.

This study revealed a gendered pattern: women in particular reported higher levels of concern but lower levels of knowledge regarding climate change. Therefore, teaching could usefully focus on strategies for raising awareness, which could reduce unnecessary concerns. It has been shown in earlier research that climate-related anxiety decreases as knowledge increases (Zacher and Rudolph 2023). As a consequence of this, we suggest that further investigation into the relationship between climate-related concerns and anxiety could provide valuable insights into how education could support wellbeing among young people with regard to climate change.

In terms of future research, the current study could be expanded by addressing its methodological limitations, for example by examining more diverse student populations across different regions and educational levels. In addition, future studies could examine whether students' attitudes change over the course or whether their motivation predicts their attitudes. Previous research has also highlighted temporal variability in situational motivation (Törmänen et al. 2025), suggesting that examining temporal dynamics in climate education modules could improve understanding of the factors influencing student interest.

Furthermore, climate education encompasses multiple dimensions beyond physical phenomena, which may have influenced the findings of this study. Future research should therefore consider different aspects of climate change knowledge, particularly those involving human–environment interactions and socio-economic perspectives. Previous studies have shown that female students, for example, may be more interested in other scientific domains (Osborne, Simon, and Collins 2003), suggesting that the focus of climate education could be examined from different disciplinary perspectives. Emphasizing economic and societal dimensions of climate change may provide a more comprehensive understanding of student engagement. Effective multidisciplinary climate education could help to develop systemic critical thinking and multiliteracy skills among students, while fostering their civic engagement (Baltikian, Karkkainen, and Kukkonen 2025). Finally, future research could fruitfully investigate pro-environmental actions among students, given that attitudes towards and knowledge about climate change are known to influence behaviour (Harker-Schuch and Bugge-Henriksen 2013).

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Author contributions

CRediT: **Inka Niikkonen**: Formal analysis, Methodology, Visualization, Writing – original draft; **Veli-Matti Vesterinen**: Investigation, Methodology, Supervision, Writing – review & editing; **Elisa Vilhunen**: Supervision, Writing – review & editing; **Jari Lavonen**: Conceptualization, Project administration, Supervision, Writing – review & editing.

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