

# Teacher agency in using students' questions in climate change education

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## ABSTRACT

This study investigates teacher agency when teaching about climate change (CC) using a question-based approach. The study was implemented as part of an international project in which teachers' CC teaching was supported by teacher educators. Teacher agency was studied using semi-structured interviews, which were coded using theory-based content analysis. The study demonstrates that all theory-based agency factors can be identified using this data. In addition, teacher agency was shown to be affected by (a) teachers' background, especially their sustainability and environment-related background, (b) cultural interaction, (c) the learning environment, (d) discourses in society, and (e) teachers' thoughts regarding useful principles of CC teaching. We suggest that teacher education should support teachers and schools in the collaborative planning of challenging topics, such as CC. In addition, as teachers possess valuable knowledge and ideas on CC teaching, they should be participating in curriculum planning.

**Keywords:** environmental education, question-based approach, professional development

## INTRODUCTION

'Oh, is this a lake? Is this a river? Is this a sea?' and 'What is this ... is the ice melting?' and 'Is this in the morning or in the afternoon'. I responded, 'well it's not a river, it's too large', 'no, maybe it is the sea, not the sea ... there are no waves.' And then one of the pupils said, 'these are two children, they are looking for their future that is melting' (T5 [teacher 5]).

These questions were asked by children when their teacher showed them a picture of two children looking for a melting iceberg. The children were asked to observe the picture as part of a school project, which aimed to teach the students about climate change (CC) using a question-based approach (QBA). With QBA, teachers use the students' questions in different ways in their teaching (Herranen & Aksela, 2019). CC is one of the greatest present-day environmental challenges faced by society (Kulmala, 2018). Climate change education (CCE) aims to respond to this challenge by increasing the general public's and especially the next generation's understanding and awareness of CC and a more sustainable lifestyle (UNESCO, 2010). Teachers have a crucial role in supporting sustainable

development because they are teaching future decision makers. Therefore, teacher education needs to support teachers in bringing new approaches, methods and contents into schools to enhance sustainability discussions (Koskela & Kärkkäinen, 2021). According to Tolppanen and Aksela (2018), students' questions are an important resource for teaching and learning science in the context of CC. Considering these aspects, the international program aimed to collaboratively promote teacher agency in teaching CC using QBA.

It seems that teacher agency affects their professional development (PD) and how they respond to this challenge. According to Biesta and Tedder (2007), teacher agency is something they can achieve and not only possess. Koskela and Kärkkäinen (2021) suggest that the concept agency is appropriate when studying the interplay between the aims and actions of individuals and their physical and social environment. This study thus approaches CC teaching through a focus on teacher agency.

The study investigates teacher agency when teaching about CC using a QBA. The specific research questions are, as follows:

1. What theory-based agency factors are apparent when teachers plan CC teaching using QBA?

2. Which issues related to these theory-based factors affect teacher agency?

### Climate Change

CC strongly affects human well-being and the environment. CC refers to change in the state of the climate usually over several or more decades. For instance, the atmosphere and oceans have warmed, the amount of snow is decreasing, and sea level is rising. The changes affect, e.g., biodiversity, water resources, food production and soil erosion. It also has notable effects on societies and economies (IPCC, 2021).

Both natural factors and human factors cause CC. However, humans' own actions are the dominant cause of CC because of increased greenhouse gas emissions into the atmosphere (IPCC, 2021). For instance, the concentration levels of carbon dioxide in the atmosphere have risen steadily from 316 ppm to 421 ppm (as of May 2022) since 1958 (NOAA, 2022, June 15). The main driver of CC is the enhanced greenhouse effect in which greenhouse gases, such as carbon dioxide, absorb too much of the Earth's infrared radiation. This process creates energy, which is released into the atmosphere, thereby leading to global warming and other serious consequences (Zein & Chehayeb, 2015).

### Using Students' Questions in Climate Change Education

The role of education in facing great environmental challenges has been acknowledged as a key factor in many research studies and programs (Anderson, 2012; Sihvonen, 2020; UNESCO, 2014). It enhances people's understanding and raises awareness of how to achieve a better balance between nature and humans and how to solve environmental problems (Sihvonen, 2020).

Effective CCE focuses on personally relevant information taught by active, engaging and student-centered teaching methods (Monroe et al., 2019). The meaningful engagement with the environment is enhanced if the learners are seen as the owners of knowledge and learners' experiences are considered in teaching (Sihvonen, 2020). Herranen et al. (2018) suggest that students should be given more opportunities to drive their own learning and contribute to learning community.

Engagement can be supported through, for example, with QBA. With QBA, learners are guided to form and refine guiding questions (Heick, 2022), and their questions can be used to direct inquiry practices (Crawford et al., 2000). Therefore, pupils' thoughts, knowledge and experiences become more visible. QBA emphasises the quality, refinement and effect of the questions, which can be scored, graded, published and acknowledged in the same way as traditionally done with a question and answer format (Heick, 2022).

Teachers can use students' questions in various ways in teaching. They can give students a driving question, improve the quality of the pupils' questions and formulate questions together with the students as research questions. Moreover, teachers can teach the topic at hand or inquiry skills, or they can let the students learn them before moving into the question formulation phase. During the inquiry phase, the teacher can encourage students to devise questions that the class can answer together, to inquire, discuss and formulate

questions as part of a collective process (Herranen & Aksela, 2019).

It is reported that students enjoy conducting inquiries based on their own questions and the questions are an important resource for learning science (Chin & Osborne, 2008). According to Tolppanen and Aksela (2018), students' questions about CC are linked to a variety of perspectives such as scientific, social and ethical aspects.

### Supporting Teachers' Professional Development in Climate Change Education

Teaching CC causes big challenges for many teachers. For instance, CC knowledge is cross-disciplinary. Furthermore, CC models are based on uncertain and partial data, which is something that the teachers are not necessary used to. Teachers also have to consider social aspects such as how CC challenges people's attitudes to the environment and commitment to personal and communal action (Oversby, 2015). Therefore, it is obvious that teachers need support and possibilities to develop their knowledge and skills in teaching such a challenging subject as CC at schools.

Teachers' PD refers to a life-long and continuous process of teacher learning (Galeon et al., 2019). It is related to activities that develop teachers' skills, knowledge, expertise and other characteristics as a teacher (TALIS, 2009).

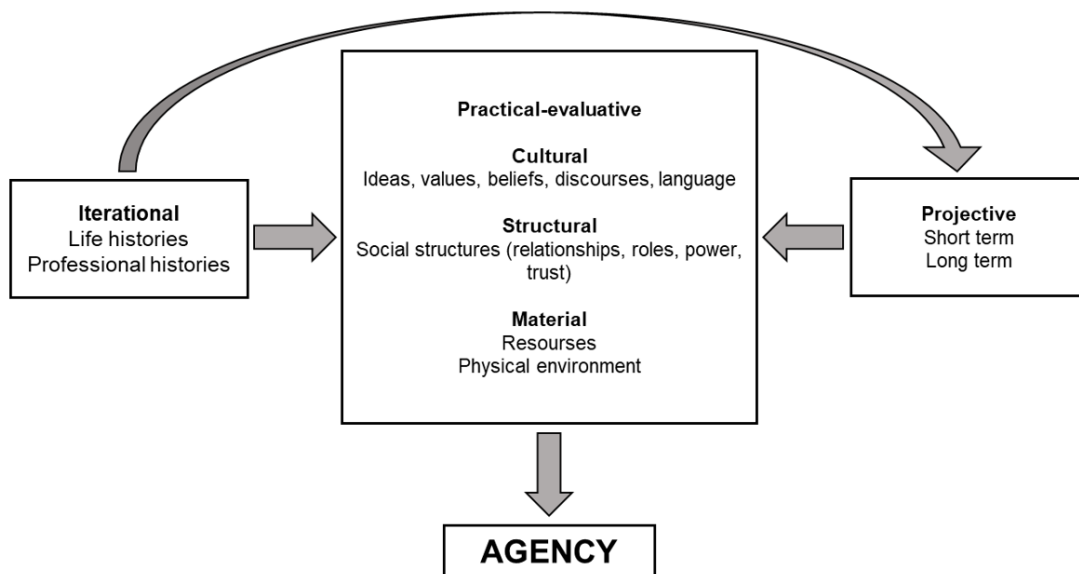
According to Hunzicker (2011), Le Fevre (2013), and TALIS (2009), applying new information to teacher practices in school classrooms often initially fails. Le Fevre (2013) points out that teachers may feel the fear of public failure when applying new practices to teaching. Therefore, the challenges should be discussed openly, and teachers should feel that all the members of the school support them and that sharing their practices is safe.

Hunzicker (2011) argues that an effective PD education considers teachers' needs, concerns, interests and life experiences. In addition, it tailors education based on how teachers want to learn and what teachers feel is necessary to learn. Education should also account for the fact that adult learners value learning from and with one another and are motivated to address problems and create solutions that are related to their lives. Hunzicker (2011) also states that observing pupils' learning outcomes to assess the relevance of new knowledge and skills may enhance changes. Activities such as coaching, mentoring and study groups support teachers in considering possibilities, trying new things and analysing the effectiveness of their actions.

### Teacher Agency

Priestley et al. (2015b) consider teachers as essential agents of change and emphasise their continuous PD. Depending on the school system and culture, teachers have different opportunities, autonomy and capacity to influence their own professionalism, school practices and curricula (Priestley et al., 2015a). Biesta et al. (2015) argue that teacher agency is an important part of teachers' professionalism.

The term 'agent' indicates 'a being with the capacity to act'. Therefore, an 'agency' embodies the intentional or unintentional exercise or manifestation of this capacity (Schlosser, 2019). Priestley et al. (2015a) argue that the term is



**Figure 4.** Ecological model of teacher agency (adapted from Priestley et al., 2015a)

often applied loosely in literature. A broader collective discourse on the issues affecting it is required (Biesta & Tedder, 2007).

In this article, we share the view of Biesta and Tedder (2007) that teacher agency is something that they can achieve and not only possess. Moreover, we consider teacher agency to consist of the following features:

1. Teachers' capability and capacity to act intentionally to direct their professional growth, to create solutions to professional challenges and to improve their professional skills, practices and knowledge.
2. Teachers' capability to make decisions based on classroom needs or their self-reflective thoughts and considerations.
3. Teachers' willingness and capability to act, reflect and make changes (Engeness, 2020; IGI-Global, n. d.; Molla & Nolan, 2020).

We chose an ecological approach to teacher agency (Priestley et al., 2015a) for our study because it offers a methodological and theoretical framework for understanding how teachers achieve agency. The approach is built on agency concept analyses by Biesta and Tedder (2007) and Emirbayer and Mische (1998).

Based on the ecological approach, agency emerges when individual capacity interacts with surrounding conditions. Agency is both relational and temporal because 'humans operate by means of their social and material environments' and 'their agency is rooted in past experience, orientated to the future and located in the contingencies of the present' (Priestley et al., 2015a, p. 19).

According to Biesta and Tedder (2007), agency is something that people do or achieve. Humans always 'act by means of an environment rather than simply in an environment' (Biesta & Tedder, 2007, p. 137). Therefore, it is understandable that agency may be achieved in one situation but not in another. It also fluctuates throughout an individual's lifecycle. Our past experiences affect present and future actions (Biesta & Tedder, 2007). Thus, 'the achievement

of agency will always result from the interplay of individual efforts, available resources and contextual and structural factors as they come together in particular and, in a sense, always unique situations' (Biesta & Tedder, 2007, p. 137).

The ecological model (Figure 1) assists researchers in understanding teacher agency. The model's three dimensions developed through varying and dynamic interplay between them are iterative, projective, and practical-evaluative (Priestley et al., 2015b).

The iterative dimension of agency expresses how agency builds on past human achievements, understandings and action patterns. However, people are able to recognise their past behaviour, select the appropriate patterns, refashion them to suit present purposes and engage them in future expectations. Our personal capacity, professional and personal beliefs, and values are also rooted in the past. Therefore, in teacher education it is important to encourage and engage teachers in a reflective mindset. Dialogue with colleagues, exploring the school culture and having an innovative and encouraging work environment all positively affect teachers' PD (Priestley et al., 2015b).

The projective dimension of the model expresses human intention to learn from past experiences and orient oneself towards the future. The achievement of agency is driven by human hopes, fears and desires for the future. Future limitations are estimated, motives, goals and intentions are clarified, and structures of thoughts learnt in the past are reconfigured. A new moral and practical course of action is identified, one that represents a combination of short-term and long-term objectives and values (Priestley et al., 2015b).

The third element, the practical-evaluative dimension of agency, highlights that agency is achieved via constructed engagement with a differing context over time. Agency can only be implemented in the present, and therefore the present is the main driver of agency. The dimension considers social processes, physical resources and physical constraints. This dimension enables agency by shaping decision making and actions. At times, the created perceptions of risks hinder undesirable results (Priestley et al., 2015b).

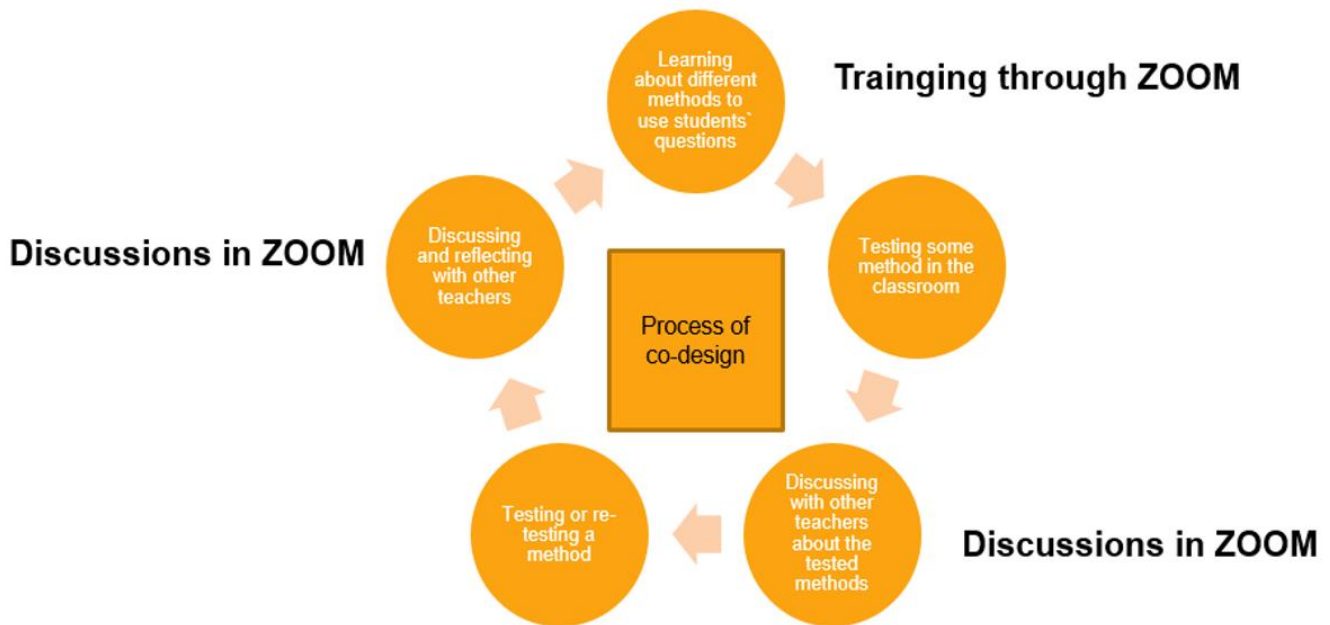


Figure 2. Co-design process (Source: Authors' own elaboration)

## MATERIALS AND METHODS

This is a qualitative study of teacher agency using a QBA in the context of CC. Qualitative methods focus on creating a holistic view of the necessary issue and discovering the meanings that participants assign to it (Creswell, 2014), in this case CC teaching via QBA.

The study was implemented by investigating teacher agency during an international and multidisciplinary teachers' PD project. The project brought together a total of 25 teachers, who teach in many different education levels, from South America, Asia and Europe and the teacher educators from the an anonymized university. The goal of the project was to support teachers in their PD in CC teaching and in implementing new pedagogy (QBA) in their classes, thus improving their agency. The program lasted one academic year.

The co-design process is described in **Figure 2**. Teacher educators offered training on how to use students' own questions in CC teaching and taught and shared information about CC on a virtual educational platform. Teachers were encouraged to test QBA in CC teaching with their own students. Their ideas, experiences, possible perceptions and fears were discussed, shared and reflected on in joint virtual meetings with all participating teachers as well as in smaller groups of teachers. As an example, what kind of experiences the teachers shared in meetings and their diaries, we present some of those in order to paint a picture of the study context.

Questions were seen as a philosophical approach in learning processes to continuously assess pupils' understanding. For instance, the first step in learning process was that pupils were asked to share their knowledge of CC in the classroom. Teacher let information and the raised questions flow freely or guided the discussions. Moreover, a teacher aimed to guide a scientific process with pupils' questions when exploring the nature with them. Moreover, teachers aimed to promote discussions and critical thinking by

tasks, which were based on students' questions. For instance, students were asked to create questions of CC related photos. These questions were discussed together. Sometimes pupils were asked to create questions to each other after they had investigated and gotten a broader view of a specific CC topic. The activity was implemented as a mobile quiz game.

Often teachers aimed to arouse pupils' questions by considering challenging events such as floods and droughts caused by global warming in the tasks. Sometimes the necessary information was very close to them personally because impacts resulting from CC, such as floods, have affected their everyday lives. The children were challenged to talk with the villagers, who had experienced the floods. In addition, they were asked to read and make questions of the news related to CC effects on their living environment. Teachers also tried to tie the activities to the learners' starting point, thoughts and opinions. For instance, the photo, where kids were swimming in a water full of trash led pupils to make questions of sustainability from many different perspectives.

These experiences with QBA, CC teaching and their group work were then studied via semi-structured interviews (see **Appendix A**). Seven teachers agreed to be interviewed at the end of the project.

The semi-structured interviews included open-ended questions so that teachers could discuss in their own words what they thought was important and significant about the topic. We also clarified questions if necessary. Therefore, the interview was not carried out in the exact same way or order with each interviewee (see e.g., Hobson & Townsend, 2010). The interviews were conducted individually through Zoom. On average, they lasted 27 minutes. The interviews were transcribed verbatim, and the analysis was done using those transcriptions. The interviews were analysed using inductive content analysis (Elo et al., 2014; Krippendorff, 2004). More precisely, we used theory-driven inductive content analysis following the ecological approach to teacher agency (Priestley et al., 2015b). We used ATLAS.ti (version 9.1.7.0) for analysis.

**Table 1.** Coding units & how often they appeared in the data

Coding unit	n
<b>Practical evaluative</b>	<b>574</b>
Cultural	256
Structural	202
Material	116
Physical environment	54
Resources (time was considered a resource)	62
<b>Iterational</b>	<b>137</b>
Life histories	42
Professional histories	95
<b>Projective</b>	<b>103</b>
Long term	44
Short term	59

First, we coded the data into coding units, which were cultural, structural, material, life histories, professional histories and short- and long-term thoughts. These units were based on the categories as part of the ecological approach to teacher agency (Figure 1).

Our goal was to discover how teachers discussed and the extent to which they emphasised three dimensions of agency (Priestley et al., 2015a), iterational, projective and practical-evaluative, in their responses. The material unit was further coded into subunits relating to physical environment because we were interested in how teachers' experiences affected the meaning they assigned to the environment in their teaching. Although we were able to divide the iterational and protective dimensions into two subcategories, we were not able to do the same for the other categories because such concepts as beliefs and values are not distinct enough.

The coding consisted of two rounds of analysis. The first round revealed clear similarities and connections between the different categories of coding units. The theory posits that teacher agency develops in varying and dynamic interplay between these three dimensions (Priestley et al., 2015b). To understand this interplay, we therefore conducted a second round of analysis by grouping similar units into new categories. We then grouped the categories into broader themes based on their similarities (Krippendorff, 2004).

Validity in this study was addressed using three persons (authors) to code the data. The coding was discussed amongst all three authors to reach consensus. Data was also coded in two phases to increase validity. Since the interviewees were not native English speakers, we carefully read the transcribed text to understand what they really meant. To ensure that the data was not taken out of context, we regularly revisited the entire interview during coding.

Reliability was addressed by calculating Cohen's kappa from a text segment from one of the interviews before the two coders discussed it with the third one to reach consensus, as follows:

$$\kappa = 1 - \frac{1-p_0}{1-p_e}$$

where  $p_0$  is the relative observed agreement among raters and  $p_e$  is the hypothetical probability of chance agreement. The kappa was 0.42, indicating that the level of agreement was moderate.

## RESULTS

The first research question was, what theory-based agency factors are apparent when teachers plan CC teaching using QBA?

We found that all the factors based on the ecological approach to teacher agency (Priestley et al., 2015a) appeared in our coding (see Table 1). We observed that the main category, practical-evaluative (including the units related to cultural, structural and material), was emphasized in the responses (n=574). Alternatively, teachers' life histories and professional histories (iterational) and their short- and long-term thoughts (projective) received less attention in the interviews (n=137, n=103).

The second research question was, which issues related to theory-based factors affect teacher agency?

We discovered eighteen categories, including the coding units discussed above (see Table 2). Those categories were allocated under different themes to clarify the various issues that affect teacher agency most apparent when interviewing the studied teachers.

### Teachers' Background

A strong relationship with nature and sustainable thinking was common among the participating teachers. The interviews indicated that the teachers' own growth environment and relationship with nature plays an important role in how they perceive CC teaching. As one teacher noted:

'My father was a farmer, so I was used to staying in the country, to have contact with the ground, with the flowers, with the animals. And so, I was always interested in preserving and protecting them ... Now I am already interested in this topic' (T5).

Some teachers and their community reportedly have a desire to protect nature because they have faced new challenges in their daily lives because of CC. One teacher (T6) said:

'We used to have snow during the winters, and now there is less and less snow ... several years ago there were messy floods ... very, very bad situation, and then they (community) would be concerned. It's something that would influence my life personally.'

Another added:

'I can see how much less water I have in the well at my house ... how much less water there is in the river ... I'm touched by this topic' (T2).

The teachers' professional life history showed that they value education and educational research highly. They reported having continuously developed their skills by, e.g., searching for information from the university web pages, participating in teacher forums, conferences and STEM clubs, writing articles and taking pedagogical courses.

**Table 2.** Agency themes & categories

Themes	Categories
Teachers' background	Relationship with nature & sustainable thinking
	Teachers' strong desire for continuous learning
	Belief in positive impact of people's own actions
Interaction & culture	Importance of people's values & attitudes
	Importance of teacher collaboration
	Teaching traditions
Learning environment	Teachers, pupils, & locals as climate role models
	Question-based approach
	Support for & resources of climate change project
Society & climate change education	Challenges in teaching climate change
	COVID-19
	Discourses in society
Teachers' thoughts regarding useful principles of climate change teaching	Society's commitment to climate change education
	Role of climate change teaching & teachers at schools
	Teachers' belief in climate change as a cross-curricular topic
	Do-it-together tasks
	Physical environments of learning
	Teachers' belief that children are a key to change

The teachers reported being quite concerned about the state of the environment and impacts of CC on humans. They generally noted that they do not have enough CC knowledge and that the topic is difficult to teach. Therefore, they expressed a desire to learn more about CC and new approaches. It is noteworthy that most teachers had years of experience in implementing new approaches in their teaching. Several teachers had reportedly done many environmental projects with their pupils over the years.

Some teachers pointed out that CC should be viewed from many different perspectives. This requires teachers' willingness to learn from each other. 'I try to bring this experience with the others, because only if we create teachers' sense of collaboration can we realise something good', said one teacher (T2).

Belief in the positive impact of people's own actions in mitigating CC became visible in the responses. T3 described how they changed their lifestyle for example by buying local food, using public transportation, making some products themselves, and protesting against trashing.

'... because as one person you can do a lot and then we can spread this to all the world. So, I do not just want to talk about it; I also do some action' (T3).

According to another teacher (T5), pupils are not used to reflecting on their own living habits. It is a teacher's responsibility to increase awareness about the consequences of people's actions:

'We have the possibility to change our life. We can decide to use a car or a bicycle ... We can decide not to eat fruits that come from other parts of the world ... if you like to make a change, we need to make something concrete every day of our life' (T5).

Some teachers highlighted that people's values and attitudes as well as changes in them should be regarded in the learning processes. They expressed the idea that teachers can support pupils in finding their own ways to preserve nature and become empowered to address the problems.

An example cited by one teacher (T7) shows how questions can awaken pupils' curiosity and may lead to changes in values and attitudes. Teacher showed children a picture of a child swimming in water full of rubbish. Teacher asked, what is going on the picture. Children responded that he is swimming in garbage because he's poor. Teacher wondered out loud, is it possible for a poor boy to buy that kind of products and why is he swimming in the trash. Then, teacher showed children a picture of a beach full of garbage to show that the problem is even bigger. Children started to think do they really need all the products they usually buy and is it possible to change their habits. Children had a new idea: 'okay, let's change the plastic balloons for garlands'. Teacher thought that children identified with the children in the picture.

### Interaction and Culture

Interaction was the strongest theme that emerged from the analysis. The teachers reported feeling quite strongly that collegial interaction, working with external collaborators and using educational platforms increase teachers' motivation, conveys an understanding of CC between the stakeholders and improves the mitigation of CC. Interestingly, a lack of support and pedagogical development in teachers' own schools instils them with stronger professional agency to seek out new opportunities.

Most of the teachers reported feeling that they did not receive enough support for this project from colleagues in their school and have not succeeded in involving colleagues in the project. They assume that such low collegial involvement was due to the COVID-19 pandemic and a lack of time, adequate CC content knowledge and interest. Moreover, a high turnover rate among teachers, weariness and a tradition wherein teachers are used to working alone may also impact involvement in general. The interviewed teachers feel frustrated and alone in such endeavours and expressed a desire for better collegial support.

Although team teaching is included in the national curriculum in some countries, teachers often find it difficult to work together with other teachers:

'It's not so easy because we are used to working alone' (T5).

In addition, local curriculums, resources and traditional teaching cultures do not support teamwork. Regardless of the teachers' experiences, they expressed a willingness to be agents of change for better collaboration. In those schools, where collegial collaboration was supported and the planning atmosphere was positive, teachers reportedly share and integrate ideas and experiences. They implement team days, interdisciplinary learning classes and sustainability projects. Moreover, the locals become involved in such school projects as well.

Teachers used the term 'traditional teaching' when describing common teaching methods with following examples in their schools:

'We are not used to observing them [students]; usually we just ask them closed questions to give them the scores and marks ...' (T1).

Another teacher said:

'We're going to read page 35 in our book of science. What is important on this page? Can you summarise this in your notebooks? Easier for the students and for the teacher too' (T5).

Teachers also reported that for the most part, the teaching traditions in their countries do not support the idea of pupils creating and asking questions. Instead, teacher-centered methods are more common. Many teachers had also noticed that some of their pupils are shy and are not used to speaking aloud in a classroom. One teacher worded it in this way:

'We are not fan of questioning ... we are mostly quiet, and we are listeners. So, this something very new for us. So, I think that we have to do much more, and of course myself too, on this. How to question, and especially, how to build questions and how to answer questions, especially on these topics' (T4).

Although many teachers pointed out that it is challenging to change teaching traditions, they positively look to the future and seem convinced that such change is possible and is coming. As one of the teachers said:

'We always need to take the first step, small steps ... and we should not be discouraged.'

Many parents do reportedly encourage the teachers in making changes as well, although they at times express that they are worried about the new teaching methods.

Teachers highlighted the importance of the teachers' role in being climate role models and inspiring pupils to engage in concrete CC actions, since children also learn by observing others, by doing and by reflecting on their experience. Some teachers highlighted children's role in CC knowledge transfer. Thus, the information learnt affects people outside the school as well. One pupil told to teacher (T3):

'Oh, if my mom forgets to take the bags with her to the shop, I will inform that she should take the bag that I

have made from old t-shirts to avoid too many plastic bags'.

In the school projects with the local community, the locals, teachers and pupils can all be role models for each other.

Teachers suggested that those locals who have experienced the negative effects of CC, such as flooding and drought, could share their knowledge with pupils and teachers. Some teachers had experienced that history itself, such as the resulting deterioration of statues, monuments and historic sites, can serve as a model in learning about how CC has affected people's lives and the environment.

### Learning Environment

QBA challenged the traditional classroom experiences of most teachers and pupils. However, the teachers felt that adapting QBA greatly changed their way of thinking about teaching and learning. Moreover, they felt that their pedagogical and CC competence increased.

In the end, most teachers were astonished at how well pupils created questions and how actively they participated in the discussions. Some teachers highlighted the natural curiosity of children, suggesting that QBA is a natural approach to teaching and learning. Moreover, teachers think that pupils' capability to ask questions reveals much about their thinking skills. Some teachers discovered that when using QBA, their pupils' motivation increased, they were more interested in the topic and their learning outcomes improved. They pointed out that QBA is suitable especially when teaching ethically important topics, and questioning invites pupils to directly to action.

Teachers pointed out that 'the work and learning of pupils became more visible'. As one teacher (T1) commented:

'I could observe them better. I noticed that even though the learning and the teaching were online, I could keep my attention focused on students, because the fact that they were involved in such a student-centered perspective made them really the protagonists of the experience. I think that was the most important and effective difference I noticed.'

According to the teachers, QBA gives students a chance to express their opinions and views. It is a more student-directed approach; when the students plan and schedule their own projects, this calls for personal responsibility and concentration. QBA also promotes critical thinking and metacognitive skills. For the teacher, QBA increases their reflection on their own teaching and gives them the possibility to concentrate on the students instead of their marks. The cons of the approach are that QBA requires more time for planning and implementing in classes than do traditional teaching methods and that evaluating students is more challenging due to the variety and type of tasks. Not all teachers and parents are familiar with QBA. In addition, students and their families are often not convinced that learning can take place with new methods.

Teachers reported that they have used media as a resource for the project. For instance, teachers gave pupils the task of following CC news, and teachers retrieved information from

the internet for them by reading scientific articles, CC websites and educational materials published by universities.

The project's CC platform supported teachers by giving them ideas and examples of how to implement QBA in teaching. Moreover, teachers reflected that becoming familiar with recent educational and CC research developed their professional skills and interest. Some teachers also noted that collaborating with university researchers and taking part in the project outside their own school has been important to their PD. It is noteworthy that teachers were also willing to share their experiences with pedagogical experiments and their knowledge and skills in other educational forums and with the universities.

Teachers expressed the fact that international cooperation, especially discussions and planning CC lessons in teams and hearing about the experiences of others and learning from the other teachers, gave them inspiration and increased their motivation. One teacher said,

'Oh, that's a really great way to do this ... because it is a great opportunity to have other points of view, other materials and it increases my motivation to teach' (T5).

It is noteworthy that the support teachers received in teams was also emotional at times. Teachers offered encouragement to each other and expressed compassion. One teacher (T5) explained:

'You have a lot of things to do at school, so maybe sometimes you're like, "I have enough", ... it was important to have T1 calling, "How is it going? How are you with the project?" ... maybe you say, "oh I am tired, ... I will give up". You know. So the team is important!'

Or as another teacher (T2) put it:

'Oh! We are a great group, I can say. So, we met each other in this project, and we collaborated very well together ... when we meet, we talk together and we always find the energy, the enthusiasm, to go on. We can also share our difficulties and we can help each other.'

Sometimes also friends, families and pupils' parents showed interest in the teachers' work, which also encouraged them to continue with the project.

In general, most teachers said that the project and the interaction in teams increased their CC and pedagogical competence. One teacher (T2) mentioned the following experience:

'Online, we have a lot of real good materials, but I have to say that it's always important to have teachers with competence. If I do not have competence, I am not able to find good resources ... I can comprehend my colleagues if they have not engaged in testing a new methodology because it is always hard to go out of our comfort zones.'

Teaching new topics can create a sense of uncertainty for teachers. According to their responses, challenges in teaching CC may be caused by the following reasons:

1. It feels safe to teach CC topics only from the perspective of their own subject.
2. Teachers do not have enough time to internalise new topics.
3. CC learning outcomes are only realised after a certain delay when using QBA.
4. Teachers do not have enough confidence in their CC knowledge and teaching skills.
5. Lack of CC competence in general.
6. Lack of examples for teaching CC when using QBA.
7. Lack of necessary CC training.
8. As CC is a topic of reflection without one correct answer, it is challenging to teach and evaluate.

In general, teachers pointed out that they were stressed and tired because of COVID-19. It took time and energy to come up with new ways of working, and it was difficult to interact with colleagues and pupils. One teacher (T2) said:

'Yes, it affected [us] ... We were not present last year ... The difficulty was to engage with all the students in this instance ... teachers have used their free time to keep in touch with the students with WhatsApp for example.'

However, the impact of the pandemic on teaching was not particularly emphasised in most teachers' responses. It did not discourage most teachers, nor did they highlight the resulting shortages, such as a lack of computers, in their responses. Instead, teachers had to devise a means to continue teaching despite the challenges. For instance, if families did not have the internet or computers, then teachers used mobile phones or they tried to find a computer for the student to borrow, even if it was their own one. They also studied how to teach remotely with the help of a variety of programs and online platforms. However, most teachers highlighted the importance of interacting face to face. One teacher said:

'CC teaching needs to be, in my opinion, based on hands-on activities, definitely ... you can not collect garbage online' (T6).

As a positive impact of COVID-19, some teachers recognised that people had spent more time in nature during the pandemic and had had more time for CC thinking.

### **Society and Climate Change Education**

The teacher responses indicate that CC is widely discussed in society. However, teachers expressed that people's CC awareness varies a great deal in their countries. As one teacher (T5) mentioned:

'Someone says, "Oh, CC ... already existed in the past, no problem."'

Teachers have a strong vision that they need to maintain and achieve enough CC competence to be able to transfer CC knowledge to pupils and society and involve communities in sustainable acts. One teacher (T4) said:

'That is my mission ... I have an important role to educate these young people about these problems.'



Another (T1) put it this way:

‘This was my aim ... to underline the responsibility each student has also as an individual and also as a part of the community. So, the ethics part was interesting for me in this respect [regarding CC and QBA].’

Policy makers and those planning the national curriculum seemingly understand the impacts of CC because the national curriculum in most teachers’ home countries aims to increase sustainable skills and understanding of CC. In some countries, teachers are offered free CC courses. However, teachers may not have enough time to participate in them, and they are not necessarily paid for taking part in such training. According to the participant teachers, some teachers may also believe that the old teaching methods work perfectly well, and they are therefore not willing to participate. Most teachers mentioned that the curriculum already places many demands on teachers, such as teaching interdisciplinary entities and courses. Unfortunately, schools are not automatically provided with the necessary resources to implement them.

### Teachers’ Thoughts Regarding Valuable Principles of Climate Change Teaching

Teachers expressed that concern about the consequences of CC and the fact that they themselves have a huge role in increasing CC knowledge and understanding at schools increase their desire to learn more and act. One teacher (T5) said:

‘I have two daughters ... So, I’m really interested about the world they will live in. So, I decided to take part in this project and try my best to raise awareness about CC and especially about what every people can do to avoid CC consequences ... It is important for the people, for the world ... for them (daughters), to have a better world to live in.’

Another teacher (T2) said:

‘Only if we give knowledge and also an awareness of the importance of this topic, can we move [forward] and touch the next generation. We can grow students that are conscious about the problem, so that they can act in their future life, doing better things ... We can really affect our environment. I strongly believe this as a person, not only as a teacher’.

Some teachers have reportedly called for immediate actions:

‘We need to act immediately, so we can include it [CC] in regular subjects or extracurricular activities or find some ways to teach important topics to students’,

said one teacher (T6). Moreover, teachers expressed the belief that schools are able to contribute to increasing citizens’ understanding of CC, for instance, with collective projects.

Teachers mentioned that CC teaching should be increased in every subject. In addition, CC should be approached as a cross-curricular topic, although many are not certain that

pupils can necessarily establish connections between the subjects. As one teacher (T5) worded it:

‘we need more points of view to define, to learn, to understand something. With only one point of view, you are going to see only a part of the problem, not the whole problem or the topic.’

Another teacher (T1) reflected on how teaching CC

‘has fostered students’ ability to observe and interpret global processes in order to understand their evolution and interconnection.’

‘Knowing the global dynamics behind poverty, social injustice and migration has made students responsible for the social, environmental and cultural challenges of the time in which they live’,

the teacher added, noting that

‘they were stimulated to find common solutions for building a more equitable society’.

The teachers, however, emphasized that the effectiveness of CC teaching at schools calls for increasing cooperation among teachers. New methods could be introduced together, in small steps, alongside traditional teaching methods. Moreover, collaboration develops teachers’ CC competence, and new knowledge and skills could then be transferred to the surrounding society.

Teachers addressed the importance of do-it-together tasks in CC teaching. Local projects, visiting university laboratories, pupils teaching each other, and group work could enhance learning, many teachers thought. Many of them emphasised that the school activities should touch on children’s daily lives, and it is good to choose topics that pupils’ have enthusiastic about. This can help them pay more attention. Especially observing and doing tasks in nature is important. Pupils could learn how individual choices affect nature, and how different observations are connected to the larger CC phenomena. In addition, pupils’ awareness of how climate-friendly lifestyles can be improved. As one teacher (T7) noted:

‘They can see distortions in the species. They can see that there are new animals here that were not here before ... they are not directly related to CC or do not get to the final CC concept. They are just starting to read about nature and all. But that’s a beginning.’

Through their experiences with COVID-19, teachers concluded that meeting pupils face to face is preferable. One teacher (T6) put it this way:

‘The online environment is not quite a good environment for project-based learning or question-based learning. It is quite hard to organise that kind of activities online.’

Changing the learning environment from classrooms to virtual environments was quite challenging, even though they overcame the challenge.

Some teachers pointed out that children's enthusiasm and belief in their capabilities to change the world, suggesting that such attitudes could help promote change for the better. One teacher (T3) noted:

'My kids were talking about superheroes, that will come to the world, and they will save it, like Aquaman will drink all the river floods, and they will fly to the dry area and pour it out there.'

## DISCUSSION

The present study has investigated what theory-based agency factors are most apparent when teachers plan CC teaching using QBA and what issues related to them most affect teacher agency.

Based on existing definitions of agency (Engeness, 2020; IGI-Global, n. d.; Molla & Nolan, 2020), the participant teachers exhibited a strong sense of professional agency already at the beginning of the project. All the teachers voluntarily joined the project and took part in the research to develop themselves professionally and to promote CC learning and research on it in general. Moreover, they had been active in teaching environmental subjects before joining this project. The teachers said that they have given much thought to pupils' learning so as to better understand how they are able to meet the learning objectives. Environmental challenges, such as pollution and CC, have concerned teachers for a longer period of time; they are willing to and feel it is their responsibility to act for a better future.

The teachers in our study exhibited the capability to improve their practice, make changes and decisions, and reflect on their teaching, as demonstrated by the fact that they openly reflected on their experiences with teaching CC with QBA in teams and in the interviews. Therefore, it seems that teacher training at least maintained their sense of agency.

With respect to the first research question, we found that all the dimensions and sub-dimensions described in theory (Priestley et al., 2015b) appeared in the teacher responses. However, we noticed that teachers did not say much about their life history, nor did they say much about their professional history or how either has affected their teaching. Some teachers mentioned that having a relationship with nature in childhood has had an effect on the way they teach. Teachers who had previously experienced working and studying in an academic context related their academic knowledge and skills to their present work. Teachers' life experiences and, e.g., interests, have also been emphasised before (Hunzicker, 2011). The teachers in our study focused more on the present moment, and therefore, the iterational dimension of the theory was not observed so clearly.

The projective dimension refers to the idea that the achievement of agency is driven by human hopes, fears and desires for the future. Most teachers mentioned how worried they are about the negative impacts of CC, which some of them have already experienced in their living environment. Nevertheless, they reported feeling hopeful and believe that children are the agents of change. Therefore, the teachers had realised that they have an important role in teaching CC and

felt that they needed to educate themselves to respond to the challenge. We argue here that in the case of CC teaching, it is important to support teachers' CC and pedagogical competence so that they can become empowered to face the challenges posed by CC. As stated before (Sihvonen, 2020), it gives them hope and aids them in solving problems related to environment.

The aspects of the practical-evaluative dimension of agency emerged the most in this study. According to the theory, it is the main driver of agency. Our results indicate that among the participant teachers, some aspects mentioned in the practical-evaluative dimension did not seem to drive teacher agency that much. Especially, they reportedly do not fixate on the lack of computers or the challenges that COVID-19 brought to their daily practices. On the contrary, they said that they assumed that those issues may affect other teachers' engagement with PD. However, the teachers' responses suggest that a lack of time is clearly one of the main factors affecting teacher agency and posing challenges to their practices.

As we were also interested to assessing the dimensions of agency more specifically, we coded the interviews in more detail. Therefore, as an answer to the second research question, we conclude that teacher agency was influenced by teachers' eagerness to collaborate with one another, to learn new approaches and information about CC, and to keep on working despite the possible challenges, such as a lack of time or willing collaborators in their own schools. Moreover, they reflected on CC broadly also from a societal and cultural angle. This is in line with what has been noted before (Herranen et al., 2018). Motivated teachers do not let challenges get in their way.

The teachers in this study demonstrated a potential to consider ideas for curriculum development. It is therefore imperative that the agency of motivated teachers is considered and that they take part in curriculum planning. PD programs should also take teachers' needs into account (Hunzicker, 2011). As the studied teachers were already motivated to learn, it is important to utilise that motivation in PD programs.

In our study, teachers mentioned valuing collegial support and collaboration with colleagues, for instance in their schools and between schools and universities. Monroe (2019) likewise mentioned that it is important that teachers have an opportunity to interact with scientists and experience the scientific process. That is something that could be highlighted also in our PD courses, so that teachers might start to value collaboration with, for example, universities so much that they would find the energy to make connections with them.

According to how teacher agency is generally perceived, teachers being essential agents of change is in line with how the teachers see themselves, as being highly important, which is great. In our study, the teachers also valued their students and their questions highly, and they mentioned the importance of students being owners of their own knowledge.

### Limitations

One limitation of the study in terms of the generalisability of the results is the number of teachers studied. The teachers were also non-native English speakers, so they may have had

difficulties in expressing their thoughts on CC teaching. It would also have been helpful to see their teaching in practice, which was not possible during this study, especially due to COVID-19. However, we were able to follow teachers' projects in the meetings and from their learning diaries. Qualitative methods that we used in this study did not provide observations of possible latent factors and patterns.

## CONCLUSIONS

Based on this study, we suggest that PD courses should consider the following suggestions to support teacher agency in carrying out CC teaching:

1. Teachers' sustainability and environment-related background should be discussed in teacher education.
2. Teachers should be participating in curriculum planning, as they possess valuable knowledge and ideas about CC teaching.
3. Teachers' capability and possibilities to collaborate in their schools and with teachers from different backgrounds and outside of the school should be enhanced.
4. Teachers' PD programs should enhance teachers' understanding of CC and develop practical examples of how to carry out CC teaching and QBA.

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## REFERENCES

- Anderson, A. (2012). Climate change education for mitigation and adaptation. *Journal of Education for Sustainable Development*, 6(2), 191-206. <https://doi.org/10.1177/0973408212475199>
- ATLAS.ti Scientific Software Development GmbH. (2022). *Version 9.1.7.0*. <https://atlasti.com>
- Biesta, G., & Tedder, M. (2007). Agency and learning in the lifecourse: Towards an ecological perspective. *Studies in the Education of Adults*, 39(2), 132-149. <https://doi.org/10.1080/02660830.2007.11661545>
- Biesta, G., Priestley, M., & Robinson, S. (2015). The role of beliefs in teacher agency. *Teachers and Teaching*, 21(6), 624-640. <https://doi.org/10.1080/13540602.2015.1044325>
- Carleton, T. A., & Hsiang, S. M. (2016). Social and economic impacts of climate. *Science*, 353(6304), 1112. <https://doi.org/10.1126/science.aad9837>
- Chin, C., & Osborne, J. (2008). Students' questions: A potential resource for teaching and learning of science. *Studies in Science Education*, 44(1), 1-39. <https://doi.org/10.1080/03057260701828101>
- Crawford, T., Kelly, G. J., & Brown, C. (2000). Ways of knowing beyond facts and laws of science: An ethnographic investigation of student engagement in scientific practices. *Journal of Research in Science Teaching*, 37, 237-258. [https://doi.org/10.1002/\(SICI\)1098-2736\(200003\)37:3<237::AID-TEA2>3.0.CO;2-6](https://doi.org/10.1002/(SICI)1098-2736(200003)37:3<237::AID-TEA2>3.0.CO;2-6)
- Creswell, J. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches*. SAGE.
- Elo, S., Kääriäinen, M., Kanste, O., Pölkki, T., Utriainen, K., & Kyngäs, H. (2014). Qualitative content analysis: A focus on trustworthiness. *SAGE Open*, 4(1). <https://doi.org/10.1177/2158244014522633>
- Emirbayer, M., & Mische, A. (1998). What is agency? *American Journal of Sociology*, 103(4), 962-1023. <https://doi.org/10.1086/231294>
- Engeness, I. (2020). Teacher facilitating of group learning in science with digital technology and insights into students' agency in learning to learn. *Research in Science & Technological Education*, 38(1), 42-62. <https://doi.org/10.1080/02635143.2019.1576604>
- Galeon, D. J., Berongan, J. E., Habac, L. H., Tapales, E. L., & Galigao, R. P. (2019). Professional development of teachers in the global setting: A systematic review. *International Journal of Scientific & Engineering Research*, 10(7), 266-282.
- Heick, T. (2022). *TeacherThought*. <https://www.teachthought.com/learning/what-is-question-based-learning/>
- Herranen, J., & Aksela, M. (2019). Student-question-based inquiry in science education. *Studies in Science Education*, 51(1), 1-36. <https://doi.org/10.1080/03057267.2019.1658059>
- Herranen, J., Vesterinen, V-M., & Aksela, M. (2018). From learner-centered to learner-driven sustainability education. *Sustainability*, 10(7), 2190. <https://doi.org/10.3390/su10072190>
- Hobson, A. J., & Townsend, A. (2010). Interviewing as educational research method(s). In D. Hartas (Ed.), *Educational research and inquiry: Qualitative and quantitative approaches* (pp. 223-238). Bloomsbury Academic. <https://doi.org/10.5040/9781474243834.ch-014>
- Hunzicker, J. (2011). Effective professional development for teachers: A checklist, *Professional Development in Education*, 37(2), 177-179. <https://doi.org/10.1080/19415257.2010.523955>
- IGI Global. (n. d.). What is teacher agency? *IGI Global*. <https://www.igi-global.com/dictionary/teacher-identity-growth-mindset-and-agency/64755>
- IPCC. (2021). *Climate change 2021: The physical science basis*. [https://report.ipcc.ch/ar6/wg1/IPCC\\_AR6\\_WGI\\_FullReport.pdf](https://report.ipcc.ch/ar6/wg1/IPCC_AR6_WGI_FullReport.pdf)
- Koskela, T., & Kärkkäinen, S. (2021). Student teachers' change agency in education for sustainable development. *Journal of Teacher Education for Sustainability*, 23(1) 84-98. <https://doi.org/10.2478/jtes-2021-0007>

- Krippendorff, K. (2004). *Content analysis: An introduction to its methodology*. SAGE.
- Kulmala, M. (2018). Build a global earth observatory. *Nature*, 553, 21-23. <https://doi.org/10.1038/d41586-017-08967-y>
- Le Fevre, D. M. (2014). Barriers to implementing pedagogical change: The role of teachers' perceptions of risk. *Teaching and Teacher Education*, 38, 56-64. <https://doi.org/10.1016/j.tate.2013.11.007>.
- Molla, T., & Nolan, A. (2020). Teacher agency and professional practice. *Teachers and Teaching*, 26(1), 67-87. <https://doi.org/10.1080/13540602.2020.1740196>
- Monroe, M. C., Plate, R. P., Oxarart, A., Bowers A., & Chaves, W. A. (2019) Identifying effective climate change education strategies: A systematic review of the research. *Environmental Education Research*, 25(6), 791-812. <https://doi.org/10.1080/13504622.2017.1360842>
- NOAA. (2022). Trends in atmospheric carbon dioxide. *Earth System Research Laboratory*. <https://gml.noaa.gov/ccgg/trends/>
- Oversby, J. (2015). Teachers' learning about climate change education. *Procedia-Social and Behavioral Sciences*, 167, 23-27. <https://doi.org/10.1016/j.sbspro.2014.12.637>
- Priestley, M., Biesta, G. J. J., & Robinson, S. (2015a). *Teacher agency: An ecological approach*. Bloomsbury Academic. <https://doi.org/10.4324/9781315678573-15>
- Priestley, M., Biesta, G. J. J., & Robinson, S. (2015b). Teacher agency: What is it and why does it matter? In R. Kneyber, & J. Evers (Eds.), *Flip the system: Changing education from the bottom up* (pp. 1-11). Routledge. <https://doi.org/10.4324/9781315678573-15>
- Schlosser, M. (2019). Agency. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy*. Stanford University Press.
- Sihvonen, P. (2020). *Knowledge transfer of the holistic view of air quality: Development of a modern framework for higher education* (Vol. 227) [Doctoral dissertation, Helsinki University]. Finnish Association for Aerosol Research, FAAR. <http://urn.fi/URN:ISBN:978-952-7276-36-5>
- TALIS. (2008). *Creating effective teaching and learning environments: First results from TALIS*. OECD.
- Tolppanen, S., & Aksela, M. (2018). Addressing students' questions on climate change. *Journal of Environmental Education*, 49(5), 375-389. <https://doi.org/10.1080/00958964.2017.1417816>
- UNESCO. (2010). *Climate change education for sustainable development*. <https://unesdoc.unesco.org/ark:/48223/pf0000190101>
- UNESCO. (2014). *Shaping the future we want*. <https://unesdoc.unesco.org/ark:/48223/pf0000230302>
- Zein, A. E., & Chehayeb, N. (2015). The effect of greenhouse gases on earth's temperature. *International Journal of Environmental Monitoring and Analysis*, 3(2), 74-79. <https://doi.org/10.11648/j.ijema.20150302.16>

## APPENDIX A: INTERVIEW QUESTIONS

1. Why did you join the project?
2. What kinds of experiences have you had with teaching about climate change in general? What about in relation to QBA?
3. What kind of role does climate change play in your life?
4. Could you describe the new ideas you and/or your team created during the project?
5. How did the teamwork and our platform support your goals in teaching climate change?
6. How did QBA work for you?
7. How did your colleagues and principals, or other people in your schools, react to your project? Did you receive support? What about other people in your environment?
8. How do you think this project fits into your school curriculum?
9. How did the COVID-19 situation affect the project? What kind of material did you use? What kind of resources were available for the project?
10. What is your vision for climate change education in the future?
11. What is your mission?/What are you personally going to do?