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# Climate Change Education Challenges from Two Different Perspectives of Change Agents: Perceptions of School Students and Pre-Service Teachers

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**Abstract:** Climate change education (CCE) can play an essential role in pushing forward a climate-just transition. However, educational institutions seem to be challenged to equip students and their prospective teachers with what is necessary for them to become multipliers for climate action. This study aims to provide actionable insights on how to harness the untapped potential of CCE, overcome obstacles, and draw conclusions on which adaptations are necessary to improve current CCE settings. We conducted a qualitative questionnaire study using the example of 80 secondary school students (grade 12) and 18 pre-service teachers (PSTs). The results indicated that both cohorts feel inadequately prepared for their role as possible "change agents", stating that climate change as a topic is given too little time, engagement with practical examples on taking climate action is inadequate, and a superficial examination of the topic takes place. Students as well as PSTs as change agents are not sufficiently supported by educational institutions to exercise their transformative potential due to numerous identified challenges that have to be confronted at a systemic level. Results indicate that especially teacher training programs need to increasingly focus on the professional development of educators in this field.

**Keywords:** climate change education; climate literacy; secondary school students; pre-service teachers; change agents

## 1. Introduction

Today's young generation is completing their compulsory education at a time when the global mean surface temperature has already increased by $1.2 \pm 0.1$ °C in comparison to pre-industrial times [1]. Although world leaders have agreed to limit global warming to the 1.5 °C-threshold in the Paris Agreement, the world is currently heading towards a +2.7 °C increase of global temperature by the end of the century and thereby surpassing a "safe operating space for humanity" [2,3]. The importance of limiting global warming to the 1.5 °C-threshold is due to the fact that triggering self-reinforcing so-called "tipping elements" could lead to irreversible cascades in the climate [4,5].

Whilst the window of opportunity to mitigate and adapt to climate change is "rapidly closing" [6], researchers worldwide highlight the great potential of the education sector in playing an active role in fostering a climate-just transition [7–9]. Otto et al. [10] strengthened this statement by identifying the education system—in accordance with the "climate tipping points" [5]—as a "social tipping point". With this metaphor, the authors highlighted the prominent role of climate change education (CCE) as it opens up the possibility to help to activate social-tipping dynamics that can stabilize the earth's climate by 2050 [10]. In this context, students, together with their teachers, are seen as important

"change agents" [11–13] who are defined as multipliers of knowledge and action. They are key actors in transition processes, as they are able to contribute to key parameters responsible for change [10]. In this regard, school students can act as "multipliers for climate change awareness" [13] (p. 173) and can, for example, influence the energy-saving behaviors of their families in positive ways [12,14,15]. However, young generations have already proven by example that they are not only multipliers for climate change awareness on an individual level, but also of climate action around the world: the Fridays for Future movement has demonstrated that the demands of the young generation, as well as their placement in the climate change discourse, has not only shaped the visibility of the topic, but also influenced political decisions [16,17]. As the young generations' climate change awareness is very clearly characterized by a global and long-term perspective [18], with regard to their own behavior, they often act contradictorily: on the one hand, they want to be ecologically and socially responsible. On the other hand, they often do not want to cut back on the consumption of, for example, electrical and entertainment technology [18]. With regard to change agents, teachers can be considered as a second category of strategic information multipliers [15,19]. In addition to promoting knowledge, teachers can be seen as credible role models who demonstrate actions to mitigate climate change, which are particularly important to bring about personal action against climate change [20]. However, research on the extent of content knowledge and understanding of climate change found that pre-service teachers, as well as in-service teachers, often have the same rudimentary or scientifically incorrect understandings of key climate change concepts as their students. Common misconceptions in all three cohorts include, for example, that they confuse weather and climate or hold the ozone layer depletion accountable for climate change [21–27]. Because of this, it can be assumed that most teachers are still not well prepared to address the complex topic of climate change in their teaching [25–28].

Whilst identifying schools and universities as places of great transformative potential, they are simultaneously characterized by several systemic challenges that limit the promotion of action-oriented and participatory CCE at an institutional level. For example, Hess and Collins [29] found that, by analyzing the top 100 universities and liberal-arts colleges in the U.S., the probability that a university student takes at least one climate change course via the core curriculum is estimated at 0.17%. In addition, although several studies highlight the positive effects of specific climate change curricula for higher education, such as teacher training programs at universities [30,31] and school students' scientific literacy [32] or climate literacy [33], reforming and revising curricula towards actionable CCE at schools and universities is often challenging due to external pressures [34,35]. Additionally, it remains unclear whether teacher training programs include not only the promotion of scientific content knowledge about climate change, but also topic-specific pedagogical content knowledge in order to be able to address climate change as a Socio Scientific Issue (SSI) [36–39].

In fact, research reveals that most educational programs so far focused primarily on promoting content knowledge related to climate change, often with the notion in mind that merely understanding the scientific content side of climate change would automatically lead to action [40–42]. Although there are numerous intervention studies proving the successful promotion of climate change knowledge [41,43,44], recent research reveals that an increase in knowledge about climate change does not necessarily lead to behavioral changes [45,46]. This phenomenon is referred to as the "knowledge-behavior gap" [46]. Research also suggests that attitudes or awareness alone do not trigger climate friendly behavior automatically [47]. These studies implicate that, in addition to teaching content knowledge, other components are important too, such as political framework conditions [44] or integrating the reflection of socially controversial views and uncertain outlooks for the future [38–40] in order to promote students' pro-climate actions. Moreover, in comparison to other SSIs, the topic's urgency, resulting in an immediate urge for action-orientation and a high teaching effectiveness as well as a direct involvement can pose specific challenges for both teachers and students [14,38,39,48,49]. Feelings of guilt, a lack of self-efficacy, social norms, and

values or symbolic defense strategies might counteract action-oriented CCE [50–52]. In addition, fear and reactance among young people might increase in regard to the rising risk of climate impacts and a lack of adequate climate protection measures, which can result in depression or climate anxiety [49,53,54]. Ultimately, science skepticism, fake news, and the rise of conspiracy theories can contribute to a tense social discourse and pose a challenge to multiplying climate action [55,56]. In the context of CCE, Ojala [57] urges teachers to take students' negative emotions on climate change seriously, since teachers' respective communication styles can have an effect on their students' learning processes or even increase denialist coping strategies [57]. Jones and Davison [58] also stress the importance of integrating both cognitive and affective experiences in CCE alike in order to foster students' empowerment. Hence, teaching and learning strategies are needed that do not seek to separate feelings from facts but that actively include negative emotions in safe and trustful CCE learning environments [58]. In light of the above, it is surprising that CCE research has not yet focused on investigating in detail how to deal with a polarized and emotionalized climate change discourse in teaching scenarios [59]. In addition, rather little is known about students' and teachers' emotional predispositions when it comes to CCE in the classroom [60,61]. Thus, the question remains: What are the necessary conditions to enable powerful and effective CCE in schools to promote the educational system as an important social tipping element?

By investigating the individual perspectives on the CCE of two major target groups on an equal footing, namely secondary school students (=S) and future teachers during their university education (pre-service teachers = PST), this article aims to provide insights on how to harness the untapped potential of CCE, overcome identified obstacles and draw conclusions on which adaptations are necessary to improve current CCE settings in a cross-institutional approach. The two perspectives of possible change agents are examined along three research questions, namely (1) the self-reported potentials and challenges of acting as change agents, (2) the perceived role of educational institutions and their current CCE, and (3) the perceived affective dimension of future CCE. The findings of our study are discussed and used to develop implications for future research, educational settings, as well as the development of education policies.

## 2. Materials and Methods

This exploratory study investigates the perspectives of secondary school students and PSTs, who participated in a CCE-specific learning environment at the University of Vienna in Austria. Following a qualitative, inductive-deductive analysis approach, we present data collected in a pretest-setting, which are in accordance with numerous other educational research settings with a similar approach [51,52]. Data generation follows a descriptive and exploratory design, reflecting two different perspectives on CCE, complementing each other: the perspective of school students' as well as PSTs.

### 2.1. Context of the Study

In Austria—as part of the Europe-wide Bologna standardization of study programs and degrees—the teacher training program at universities is divided into a Bachelor- and Master of Education degree, B.Ed. and M.Ed., respectively. At all universities, as well as at the University of Vienna, where the study was conducted, the B.Ed. and M.Ed. study programs alike consist of three parts: two different school subjects as well as educational studies (pedagogy) [62]. The B.Ed. Biology program includes twelve different modules, such as biochemistry, zoology, or biology education [63]. Data collection, including PSTs and secondary school students, took place in the context of a specific CCE seminar "Climate Education for Future" [37] within the module biology education. In this seminar, PSTs are given the opportunity to plan and conduct interactive and interdisciplinary climate change workshops for secondary school students. PSTs attend this seminar regularly in their seventh out of eight bachelor semesters. At this point, PSTs have completed the majority of their bachelor's degree program, except for the bachelor thesis. Based

on a university's curriculum analysis, before entering this class, PSTs did not receive any specific training on climate change during their university education; only 2 out of 27 B.Ed. subject curricula (namely Biology and Geography) each include a single mandatory class on sustainability (2 ECTS), where climate change is addressed as only one of many environmental problems [63,64]. This finding was backed by a survey of participating PSTs on their prior experiences concerning CCE in their university career. Here, only 2 out of 18 PSTs indicated to have heard about climate change once in one of their second subjects of study before, but it was not addressed in detail. In this study, we were not interested in measuring possible effects of a CCE intervention, but rather we wanted to investigate the individual perceptions on the topic of students and PSTs; thus, data from both groups were collected before the specific CCE seminar started. As we were, in this case, not interested in the effects of the CCE seminar intervention, but wanted to investigate the perceptions on the topic of the two groups before they received any further training, data from PSTs and students presented in this publication were collected before the seminar actually started.

### 2.2. Participants and Procedure

At the beginning of the seminar, we handed out questionnaires that were completed by the participating 18 PSTs (study program: BEd. Biology, $M_{Age}$: 26; $SD$ = 6.3; 15 f, 3 m) and 80 participating 12th grade school students ($M_{Age}$: 15.9; $SD$ = 0.98; 41 f, 39 m) from four different secondary schools in Vienna. The PSTs completed their questionnaire during their first seminar unit, and students did so prior to their participation in the project. The PSTs had not been informed about the course's topic before enrolling, which is why it can be assumed that their choice to participate was not influenced by any relevant individual preferences on the topic. PSTs in our sample indicated to study the following school subjects next to Biology: Chemistry = 7 PSTs, History and Political Education = 2 PSTs, Mathematics = 2 PSTs, Geography = 2 PSTs, Sports = 2 PSTs, German Language = 1 PST, English Language = 1 PST, Spanish = 1 PST.

### 2.3. Questionnaire

To investigate participants' perspectives on CCE, we conducted a qualitative open-answer survey. The particular questions of interest were derived from a literature review. In addition to demographic items (age, gender, prior exposure to CCE), the questionnaire contained six open questions, originally in German (see Table 1). The questions were in alignment with the central concepts of interest to gain further insights into the participants' views and thoughts concerning (1) the potentials [10,12,15,49,65] and challenges [46,50,66,67] of school students and PSTs as change agents, (2) the role of their educational institutions, school and university, and their current CCE situation [14,40–42], and (3) the affective dimension, meaning both groups were asked about their evoked emotions regarding either their participation in or the teaching of climate change lessons in the future [49–52]. The questions used were slightly adapted to the respective situation of each target group. Cases with missing answers in all six questions were excluded from further analysis, leaving 78 valid responses in the sample of the secondary school students. There were no exclusions in the sample of the PSTs.

**Table 1.** Open items used in the questionnaire ($N_S$ = 78; $N_{PST}$ = 18).

| Main Category | Open Questions for S | Open Questions for PST |
|---|---|---|
| | **(A) Potentials and Challenges of Change Agents** | |
| 1 | How important is it for you to inform your colleagues about climate change and why? | How important is it for you to inform your (future) students about climate change and why? |
| 2 | What are the biggest challenges for you in informing people about climate change? | What are the biggest challenges for you in addressing the issue of climate change in your future teaching? |

**Table 1.** *Cont.*

| Main Category | Open Questions for S | Open Questions for PST |
|---|---|---|
| | **(B) Role of Educational Institutions and State of CCE** | |
| 3 | What do you think is the role of schools in combating climate change? | What do you think is the role of teachers in combating climate change? |
| 4 | Does your school education prepare you to inform your peers about climate change? | Does your teacher education program (at university) prepare you to address the issue of climate change in your future teaching? |
| 5 | In your opinion, what are the strengths and weaknesses of your school education in this topic? | In your opinion, what are the strengths and weaknesses of your teacher education program (at university) in this topic? |
| | **(C) Affective Dimension of CCE** | |
| 6 | What emotions do lessons about climate change evoke in you? | What emotions does teaching climate change in the future evoke in you? |

*2.4. Data Analysis*

The open answers in the questionnaires were transcribed, translated from German to the English language, and analyzed using methods for coding open items [68] and qualitative content analysis [69–71]. The analysis was conducted with the Qualitative Data Analysis software MAXQDA 2022. First, we assigned the responses of the six open-ended questions to six main categories (referring to each item). Next, we conducted an in-depth analysis of the data and inductively established sub-categories defined by patterns that emerged in the data. Statements were assigned to several categories if they applied to more than one. Anchor examples were defined in a coding guideline (see Appendix A). Here, the frequency of identified categories in both samples was also summarized and used for quantitative analysis. The first author and a trained research assistant applied the coding guideline, which was continuously adapted throughout the analyzing process, involving iterative reviews, discussions, categorizing, and coding. To ensure validity of the coding scheme, we conducted an inter-rater-reliability test, using Brennan and Prediger's Kappa and a randomly selected sample of 20% of all questionnaires [72]. Brennan and Prediger's Kappa revealed an "Almost Perfect" (p. 165) [73] result ($\kappa = 0.84$). For a comprehensive overview, code-theory models and one bar chart were created. In case of high numbers of sub-categories per main category, inductively established clusters were used in order to restructure the data.

## 3. Results

Findings are organized into three sections in accordance with the research questions. The first section explores the change agents' perceived potentials and challenges in informing others or teaching about climate change. The second section explores the participants' views on the role of schools and teachers in combating climate change, including the perceived state of CCE in Austria in their experience. Lastly, the third section examines the self-reported affective dimension of students and PSTs in light of the CCE lessons. Each section starts with an overview of the most common findings, followed by an exploration of in-depth findings, which serve to clarify and expand the study's results. Quotations are shown with the anonymized survey codes, followed by the sample code (secondary school students = S, pre-service teachers = PST), indicating age and gender. Results are summarized in five figures, showing the main cluster concepts. The frequency of appearance in each code can be found in detail in Appendix A.

*3.1. Potentials and Challenges of School Students and PSTs as Change Agents*

The first two questions of the survey aimed at the potentials and challenges of participants taking on their role as change agents. In this regard, the first question focused on reasons for being a change agent. The analysis of the open answers resulted in overall twelve sub-categories, whereas five sub-categories were assigned to the cluster "critical

stance" (see Figure 1). When looking at the frequency of appearance (see Appendix A), the vast majority of students and PSTs think that it is important to multiply climate change information. However, both cohorts shared different perspectives for doing so. Around 80% of the students were inclined to act as change agents, versus around 20 percent of them were inclined to take a critical stance concerning this. In the PSTs sample, all of the PSTs were in favor of teaching climate change in the future.
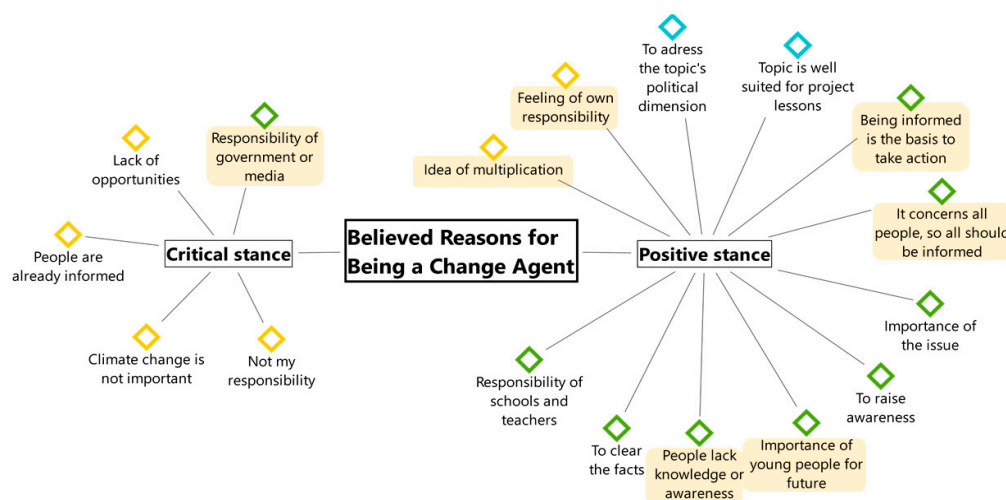


**Figure 1.** Identified sub-categories in the main category "Believed reasons for being a change agent" (yellow = S only; blue = PST only; green = both cohorts). Yellow highlighted categories are presented in further detail.

In detail, about 40% of the students thought that it is important to inform others about climate change, explaining this by being a precondition to take action and because of the idea of multiplication. More than a quarter of the students argued that climate change is a topic that affects all, so everyone should be informed. Many students felt responsible, such as EMJADE (S, 14 y, m) who asked himself: "Because if I don´t, then who knows what the future holds?". Some students also added that they think multiplying climate change information is important because they see a lack of knowledge or of awareness in others, as ASJUMA (S, 15 y, m) explained: "Too many people, including myself, are still poorly informed and are not aware of the consequences. However, people who could change a lot already know it all and don't change anything". A few others explicitly pointed out the importance of young people in this context: "Climate is important for everyone and it must be especially important for us, because we are the young generation and we must do more than everyone for our climate. We have to think like this: if we don't do something for our climate now, then one day we will be to blame." (MADEAU, S, 17 y, f). In contrast, around 20 percent of the students took a rather critical stance towards their role as possible change agents. Nine students saw little importance in multiplying climate change information because they think that people are already informed. Further, some students lacked the opportunity to do so and some students thought that it is not their responsibility alone, but, for example, the responsibility of the government or the media.

Whereas the students sample most often refers to an action-oriented or multiplicative perspective, the most common answer shared by the PSTs was raising awareness. One third of the PSTs each also mentioned the following reasons: information as a basis to take action, the importance of the issue, the importance of young people for the future, or the responsibility of schools and teachers. Here, many PSTs outlined the responsibility of teachers or schools in general to present correct scientific information and to promote students' competences to distinguish those from non-scientific ones, such as some of the students, as KADESE (PST, 23 y, f) stated: "As a teacher, it is one's job to enlighten the students so that they can distinguish between fake news and reality. It is also important to describe the consequences and what solutions there are as well as what the individual, but

also the state, can/must do". Many of the PSTs, similar to the students, also highlighted the importance of teaching climate change because of the students' youth. SAJÄDE (PST, 20 y, f) thought that "My students' generation in particular will feel the consequences of climate change much more clearly than I will" and MAJUOK (PST, 24 y, m) argued that "we must prepare the children for the future". The responses showed that the PSTs did not share explicitly the idea of multiplication in this context such as many of the students do. However, two of the PSTs added that teaching the topic is important because of its political dimension: "Climate change [...] is not only interesting from a biological point of view and thus relevant for my lessons, but also from a sociopolitical point of view", as EVNOMA (PST, 23 y, f) found. In contrast to 20% of the students, none of the PSTs took a critical stance towards the importance of teaching climate change.

In the context of challenges of informing others about climate change, or teaching the topic, both cohorts reported a wide range of different perspectives. Here, students most often referred to challenges inherent in others, while the PSTs most commonly saw their own capacities as challenging. For a better overview, the following categories were not included in Figure 2: six students that saw no challenges in informing their peers about the issue, four other students that did not specify, and five answers out of the whole student sample that could not be assigned to any category.
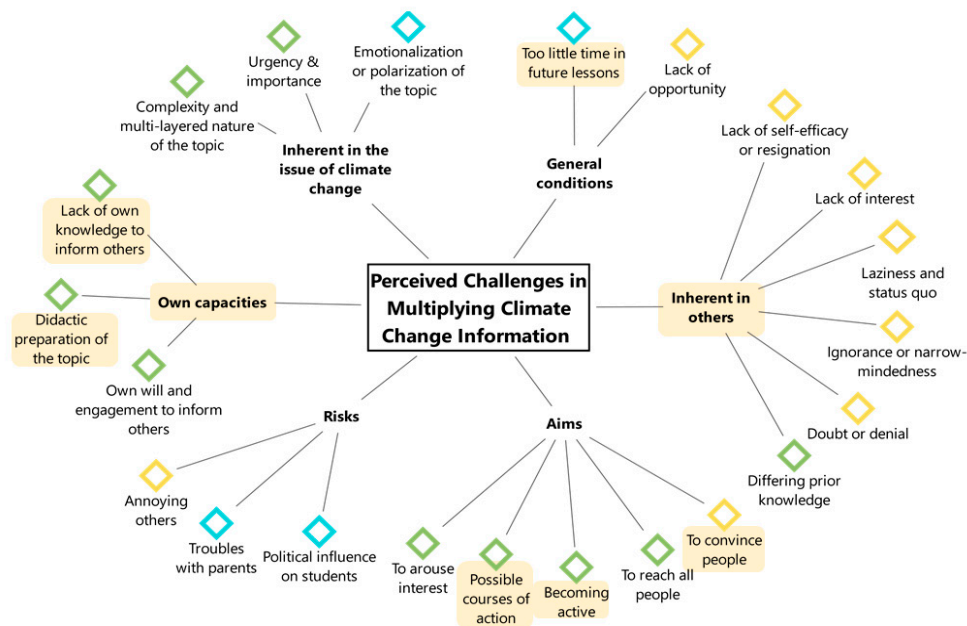


**Figure 2.** Identified sub-categories and clusters in the main category "Perceived challenges in multiplying climate change information" (yellow = S only; blue = PST only; green = both cohorts). Yellow highlighted categories are presented in further detail.

Interestingly, students most often referred to challenges inherent in other people. For example, more than a third of them indicated doubt or denial, ignorance or narrow-mindedness, or a lack of interest in other people as challenging. While SOJÄFE (S, 15 y, f) pointed out that "the biggest challenge is that many people do not want to admit its existence and deny it all and say that they are not to blame. Which is not true!!!", some students explicitly referred to ignorance, narrow-mindedness, or even arrogance. In contrast, only one PST referred to challenges inherent in others, such as differing prior knowledge.

The next two biggest clusters showed a more differentiated picture, comparing the statements of students and PSTs. Referring to aims when multiplying climate change information, a significant number of students thought that convincing others is challenging, while again no PST referred to this aspect. Naturally, the challenge of convincing others is highly connected to the reported challenges above, such as doubt or denial inherent in others. The statement of MAJUOK (S, 15 y, f) underlines this trend in the data: "Many

people, especially adults, trust some politicians and think that climate change does not exist. It is difficult to convince them otherwise". Another reported challenge presents possible courses of action to tackle climate change. Some students found it difficult to make concrete suggestions for taking action, since, to them, it is hard "to decide what can really be done and what is rather less useful" (DAFESE, S, 16 y, f), which is also the case in the PST sample. A field of tension was also noticeable in the subsequent category "Becoming active". One PST pointed out: "One challenge I see is that I do not know how to teach students the urgency of taking action NOW" (ANOKSE, PST, 25 y, f). While this aspect might be challenging to some of the PSTs, none of the students' questioned whether other people should be made aware of taking action or not. They rather referred to the aspect that it is hard for people to become active in general. For example, FIAPAP (S, 15 y, f) thought that the step of taking action is the real challenge: "I don't think it's hard to inform people, I think it's hard for people to do something about it".

Referring to their own capacities, a significant number of students thought that they lacked the knowledge to inform others about climate change. Many thought that their knowledge was not profound enough to convince others. More than half of the PSTs referred to challenges concerning their own capacities when teaching climate change; therefore, this aspect presents the greatest challenge for the sample of the PSTs. Here, the didactic preparation of the topic presented a difficulty for them, as nearly half of the sample reports. Nearly half of the PSTs also referred to the challenges inherent in the issue of climate change itself. For example, ANNOAU (PST, 22 y, f) addressed the complexity and multi-layered nature of the topic and asked herself "how to approach the topic, since the topic of climate is connected to so many areas. Where does one start and what information does one want to bring into a lesson?".

When it comes to challenges inherent in the issue of climate change, only some students pointed out the challenge of making clear the importance of the issue: "Among my peers, the people who think we have other bigger problems than climate change are a big challenge" (GUAPMA, S, 16 y, f). On the other hand, none of the students explicitly referred to an emotionalization or polarization of the topic or rather in an indirect way, whereas this presented a major challenge to one third of the PSTs. For example, EVNOMA (PST, 23 y, f) explained: "For me, the greatest challenge poses the fact how I can treat climate change as an important topic for everyone, regardless of their political beliefs. How can I avoid pushing climate change in a 'green corner' and thereby provoking that students with a different political opinion refuse to take part in the lesson from the beginning".

Few participants in both cohorts reported challenging risks when acting as a change agent. While some of the students reported that they do not want to inform others about climate change in order to not annoy them, some PSTs referred to possible difficulties with parents. MAJUOK (PST, 24 y, m) thought that the students' parents could complain about a possible influence on their students: "e.g., if you explain to the students that a vegan diet is better for the climate, then they reject meat at home and the parents complain about it".

Lastly, few students and PSTs pointed out challenges rooted in general conditions, such as a lack of opportunity to inform others or too little time in lessons.

### 3.2. Perceived Role of Schools and Teachers in Combating Climate Change and State of CCE

When asking about the specific role of schools and teachers in combating climate change, both students and PSTs most often suggested that schools or teachers should provide information. While rather few students and only three PSTs took a critical stance, the vast majority of students and PSTs described the role of schools and teachers in combating climate change in a consistently positive way, but diverse reasons could be found (see Figure 3).
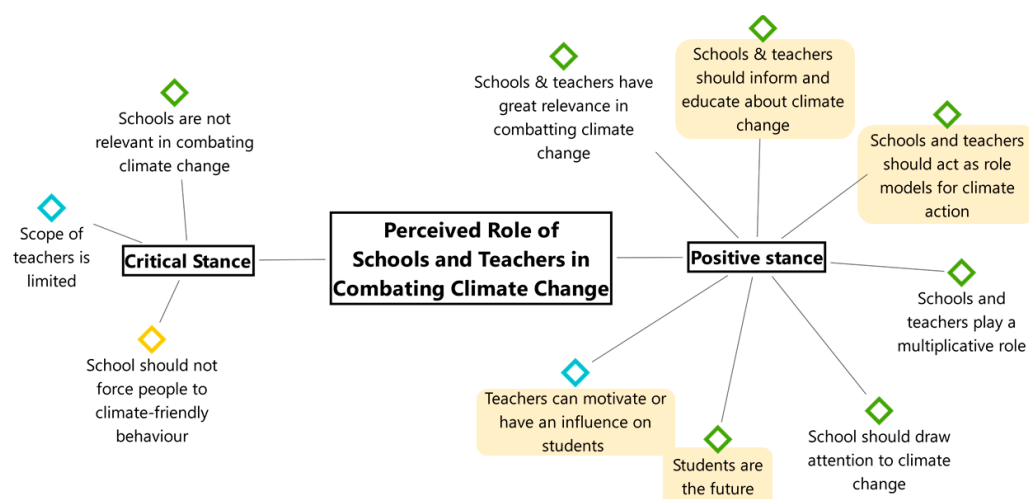
**Figure 3.** Identified sub-categories in the main category "Perceived role of schools and teachers in combating climate change" (yellow = S only; blue = PST only; green = both cohorts). Yellow highlighted categories are presented in further detail.

Referring to schools as an informing, educating agent and a very relevant one, JOJUAP (S, 15 y, m) thought "You can only change something if you know what is good/bad for the climate. It all starts with education" (JOJUAP, S, 15 y, m). Again, many students referred to the idea of multiplication and took the multiplicative role of schools into account: "A very big one, because I think, as already mentioned, that the school plays an important role in the dissemination of information" (SUFEFE, S, 16 y, f). Many students pointed out that schools should act as role models and take action too. DAFESE saw the role of schools as twofold: "The school has the role of informing what is happening and what possible solutions there are. In addition, the school community itself must also make a contribution" (DAFESE, S, 16 y, f). In contrast, one student thought that the role of the school should primarily remain an informing one: "The school should draw attention to climate change and provide information about it. However, it should not force anyone to behave in a climate-friendly way" (ELDEFE, S, 16 y, f).

In contrast to many of the students, only one PST thought that teachers should act as role models. Rather, influencing the lifestyle or actions of their future students seemed more relevant to them. Half of the PSTs suggested that teachers can motivate or have an influence on their students and/or their lifestyle. This trend becomes easier to understand when looking at the following statements. KADESE (PST, 23 y, f) was convinced: "Educated/sensitized students will act/choose/shape their lifestyle differently than students who know nothing about climate change. Therefore, the role of the teacher is a very important one". ROAPMA (PST, 21 y, f) sees here a major focus of CCE: "Students who were made aware, want to protect their future more than those who have learned nothing/little at school. Where, if not at school, can climate change be well discussed and where else could we try to encourage students to live more sustainable?".

However, some PSTs think that the scope of teachers is limited. ANNOAU (PST, 21 y, f) suggested that, in the end, the step to take action lies in the individual responsibility of her future students: "In my opinion, the teachers give an impulse, the students have to decide for themselves how to advocate for climate change" (ANNOAU, PST, 21 y, f). BAJUAU (PST, 42 y, f) was convinced that teachers "can only inform responsibly, we will not change the basic problem (capitalism, expansionism)". In the context of perceived weaknesses and strengths of their respective CCE, strong differences between the two investigated samples can be noticed concerning their perceived feeling of preparedness to act as multipliers (see Figure 4).
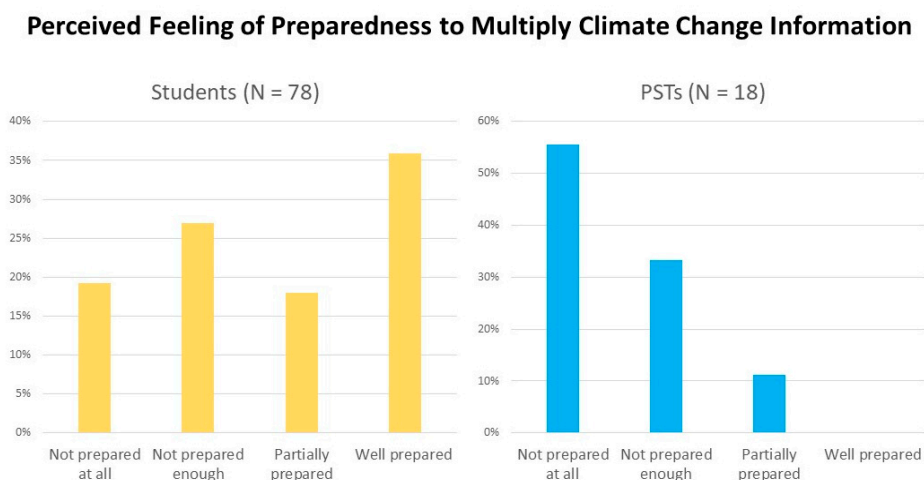
**Perceived Feeling of Preparedness to Multiply Climate Change Information**



**Figure 4.** Perceived feeling of preparedness to multiply climate change information: Relative proportion of identified sub-categories in the respective samples ($N_S$ = 78; $N_{PST}$ = 18).

In detail, 46 percent of the students claimed that they feel not at all or not prepared enough to inform others about climate change. LJJANO (S, 16 y, m) pointed out: "No, because in regular classes the topic is hardly or not at all dealt with". Surprisingly, this trend was even higher in the case of the investigated PSTs, as HEJUAU (PST, 22 y, f) explained: "This topic is not taught in detail in any mandatory class or lecture, let alone in an extra class only dedicated for it. If at all, one can only inform oneself through optional classes".

In contrast, around a third of the students' sample claimed to be "to some degree" or "well prepared".

In addition, when looking at the strengths and weaknesses concerning their specific educational context, it seems clear that the sample of the investigated students felt far more informed about climate change than the investigated PSTs. While none of the PSTs agreed, more than a third of the students reported that, in school, they were taught about climate change to some degree; although, mostly, they missed some specific aspects in their CCE, which are described in detail below. Many students thought that school succeeds in informing them about the issue of climate change, for example that they were given "good facts, articles, information, very convincingly taught" (DEAPJU, S, 17 y, m). Some students pointed out that their CCE includes practical examples or interactive elements such as visiting "many workshops, many excursions" (BEJUFE, S, 15 y, m) or that strengths include even organizing a "climate club". The following strengths of current CCE were each mentioned once by different students: "High interest from students", "Participation of protests", and "Scientific processing of the topic".

In contrast, many of the students and PSTs also pointed out reasons why they did not feel well informed about climate change and what their education program might lack (see Figure 5). The most common weaknesses in both samples included "Climate change is dedicated too little time", "Practical examples, application and solutions are missing", and "Provided information on climate change is too superficial". A student explained: "AHS (=secondary school) means the focus is on everything, not on one thing like climate change" (AMJUMÄ, S, 15 y, f). SOJÄFE (S, 15 y, f) thinks that, although their CCE succeeds in informing her about climate change, it lacks a discussion of solutions to "actively do something about it" (SOJÄFE, S, 15 y, f). DAFESE (S, 16 y, f) thought that the provided information is too superficial because "no one devotes themselves directly to the subject, but only talks about it in passing". In this context, one student and one PST each wished to have a separate school subject or course that specifically addresses the issue of climate change.
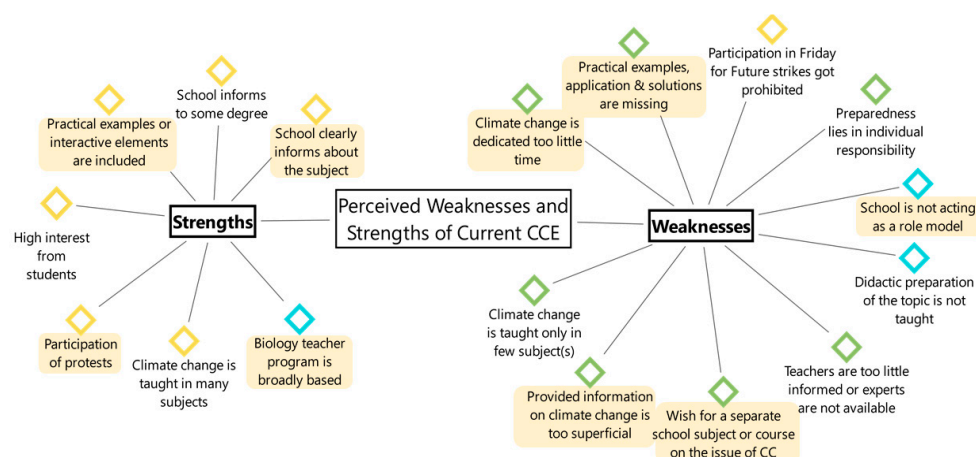
**Figure 5.** Identified sub-categories (f ≥ 2) in the main category "Perceived weaknesses of current CCE" (yellow = S only; blue = PST only; green = both cohorts). Yellow highlighted categories are presented in further detail.

Some surveyed students reported that they learn about climate change in only one individual subject, mainly in natural sciences such as geography or biology. Again, some students complained about a lack of profound discussions: "Through our school subject geography, we get some sort of geographical education, which helps us to understand the subject better. However, we do not go into such specific details" (ABJÄJU, S, 16 y, m).

Another reported weakness in the opinion of some school students was that participating in the Fridays for Future school strikes was prohibited: "We don't know how we can help alleviate it. The only thing we students can do is strike. But this is not approved by the school, which is stupid" (SAJUDE, S, 16 y, m). A few students pointed out that they think it is a weakness that their own school is not acting in a climate-friendly way. For example, "short-haul flights are organized, food is thrown away" (BEFESE, S, 16 y, f). Other weaknesses, each reported by only one student, include the lack of financial resources, that some teachers are too little informed, or the contradiction between individual teacher actions and some school principles.

As already mentioned, nearly all of the PSTs pointed out that climate change is dedicated too little time in their teacher training program. In addition, nearly a third of the PSTs reported that their CCE lacks practical examples, applications, and solutions to the climate crisis. Four PSTs highlighted that the topic of climate change is not included in their standard curriculum, but lies in their individual responsibility since "one has to actively look for courses and learning opportunities in order to be well enough prepared" (ROMÄJU, PST, 25 y, f). In addition, two PSTs pointed out that the didactic approach of the topic is not taught and that experts on the topic are simply not teaching in their university's respective teacher training program.

### 3.3. Affective Dimension of CCE

The emotions that are evoked when students and PSTs think about future lessons on climate change can be assigned into a rather negative cluster (S = 37; PST = 6), a rather positive one (S = 31; PST = 14), a cluster of rather dismissive feelings (S = 11), and a cluster of further feelings, which are neither especially positive nor negative (S = 7) (see Figure 6). Due to the high frequency of identified sub-categories, only sub-categories with a frequency ≥3 (f ≥ 3) were included in Figure 6.
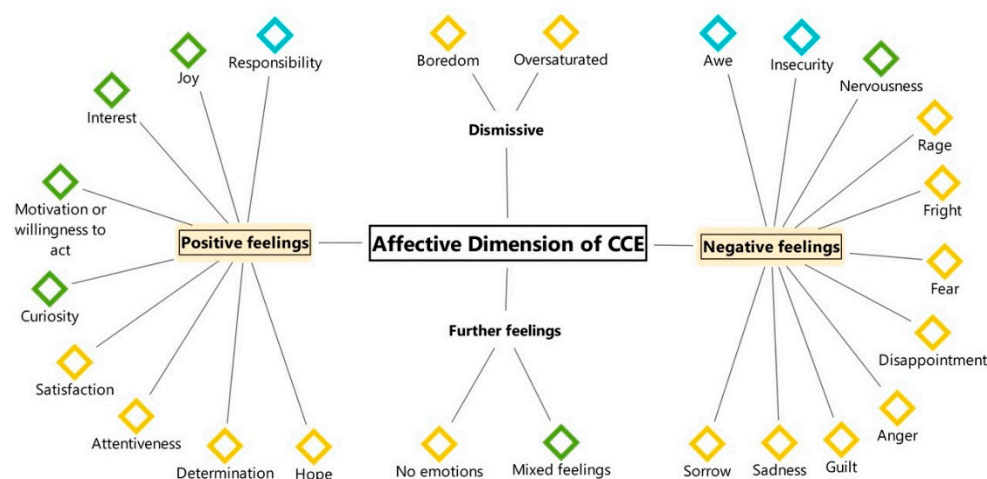
**Figure 6.** Identified sub-categories (f ≥ 3) and clusters in the main category "Affective dimension of CCE" (yellow = S only; blue = PST only; green = both cohorts). Yellow highlighted categories are presented in further detail.

Interestingly, in the case of the students, the group of those who share only negative thoughts on the topic was the biggest one (S = 21). Here, students most frequently indicated sorrow, sadness, guilt, and anger. Concerning this, it seems that many indicated feelings that are evoked when thinking about climate change and its consequences, and not only about CCE. For example, SEOKOK (S, 16 y, f) explained her feeling of sadness, whereby it is not clear if she thought explicitly about CCE or climate change in general: "It is sad when you see how nature perishes or animals die because of us. Seeing these pictures makes a difference". An amount of 18 different negative feelings shared by the students could be identified, including nervousness, fear, insecurity, rage, disappointment, and many more. VEMAMO (S, 16 y, m) stated: "I am very disappointed in humankind. Being so reckless with the Earth should not be the case in 2019. Of course, I am also disappointed in myself, how I treat the environment, but I would be willing to change/improve many habits in my life, if everyone else or a large part of the world's population would do the same". Eight students highlighted such negative emotions as shame or guilt.

A smaller number of students (S = 11) felt rather dismissive when they think about future lessons on CCE. Most of them stated that their previous CCE was kind of irritating, which is why they felt rather oversaturated by the topic, bored, or indifferent. For example, EMJADE pointed out (S, 14 y, m): "I wouldn't be that interested, because I already have roughly 10 classes, and another one would not be ideal for us students". Further, some students did not share any specific emotions at all, and two of them explicitly indicated mixed feelings.

A total of 14 students shared only positive feelings. Here, joy, interest, determination or a feeling of motivation were most often stated. For example, when thinking about future lessons on CCE, CLJUJA (S, 15 y, m) felt "glad, since then really all people get to know about it and not only the educated ones" and ALJAMA (S, 17 y, f) explained: "I think it would be important if we did more workshops on climate change, I would be really happy if we did. And maybe I would feel more like I could do something". Other positive feelings included curiosity, excitement, hope, satisfaction, and pride. On the other hand, as already mentioned, 16 students shared both positive and negative feelings, as the statement of SEDEOK (S, 16 y, f) exemplified: "Teaching about climate change creates interest and determination in me. Unfortunately, I have to say that I feel a bit ashamed for the fact that I do not act more pro-environmental". BEFESE (S, 15 y, f) also shared mixed feelings, albeit in a slightly different way: "Satisfaction, because we are finally talking about it; fear, because after all it's climate change; hope, because hopefully the opinion of some people will change to the positive, which will lead to the fact that we can stop climate change".

In contrast to the students, the PST sample seemed to show a more positive attitude when thinking about teaching climate change in the future. Nearly half of them shared only positive feelings, half of them shared positive as well as negative feelings, and two PSTs shared only negative feelings. Concerning positive feelings, the PSTs most commonly shared a feeling of motivation or willingness-to-act, joy, or interest. For example, MIMEFE (PST, 21 y, f) pointed out that she feels "anticipation to finally be able to pass on something that really has added value. We can actively participate in the improvement and animate other people to commit to the future", and HEJUAU (PST, 22 y, f) argued that, when thinking about teaching lessons about climate change in the future, she sees "a chance to teach the youth about this topic and change their behavior". In this context, some of the PSTs explained a feeling of responsibility, but mostly in a rather positive sense. Half of the PSTs also partly referred to negative feelings such as nervousness, insecurity or pressure, and therefore shared mixed feelings, as SAMAFE (PST, 22 y, f) explained: "At the moment I'm still a little nervous, because I'm not yet well prepared for it. But also great interest and curiosity. I am aware that it is an important point in biology classes, no matter what age level". Only two PSTs solely referred to "nervousness, as I might steer students in the 'wrong' direction if I bore them with my climate change lessons" (ROAPMA, PST, 21 y, f).

## 4. Discussion

This study set out to investigate the perspectives on CCE of two different target groups and possible change agents for a climate-neutral transition, namely secondary school students and PSTs. Using a qualitative research design, the following research questions were examined: What are the perspectives of secondary school students and PSTs concerning (1) potentials and challenges of acting as change agents, (2) the role of educational institutions and their current CCE situation, and (3) the perceived affective dimension of future CCE? The results and limitations are discussed in order to derive implications for future research as well as possible educational settings in order to possibly overcome the identified hindrances.

### 4.1. Individual Willingness vs. Systemic Challenges

Looking at the Believed Reasons for Being a Change Agent, our findings suggest that the vast majority of both school students and PSTs seemed to share the willingness to multiply climate change information (e.g., because of the idea of multiplication, in order to take action or because of the topic's importance. In light of the (inter)national educational missions that foresee to equip students with what they need to become active citizens in our societies [74–76], these results underline the potential of CCE for students to experience the relevance of science education and to actively contribute to shaping society). Although it is well known that young people are increasingly concerned about climate change becoming a global emergency [77], it is interesting that the vast majority of our student sample also seemed inclined to take on the role as climate change information multipliers and, thereby, would step to some extent in the shoes of their teachers. Here, many of the students described a feeling of their own responsibility and also saw their youth as important here, such as MADEAU (S, 17 y, f): "[...] we are the young generation and we must do more than everyone for our climate (see also Section 3.1). The other reasons mentioned by the students (Figure 2) also indicate high personal involvement in the issue and awareness about the social dimension of the necessary climate-neutral transition, referring to the need for multiplication and many people taking action. In the case of the secondary school students, those findings were supported by a previous study conducted in Austria and Germany [20], which concluded that the majority of students shared a high level of personal concern about climate change and willingness to take multiplicative action, while also a smaller, but meaningful group of students could be labeled as a dismissive or even paralyzed group. From the perspective of science education and research, hereby also the question arises on how to deal with student groups characterized by a greatly differing willingness to multiply climate change information, so that, on the one hand,

very concerned students do not get overwhelmed with their feeling of responsibility and, on the other hand, less concerned students can be reached at all. Concerning this, our data underlined the call that CCE settings need to take different climate change awareness groups of students into account [13,66].

In the case of the PSTs, it is noteworthy that all of them seemed to be willing to teach climate change in the future and stated numerous reasons for doing so, which is supported by a previous study on the perceived benefits of teaching climate change of around 100 Turkish PSTs [27]. To sum up, our results concerning the Believed Reasons for Being a Change Agent indicated great transformative potential for students and PSTs acting as change agents due to the high reported willingness to inform others about climate change and the various reasons for doing so.

In contrast, our findings suggest that, in most cases, educational institutions do not prepare students and PSTs sufficiently for this role, although at the same time some positive examples could be identified. While nearly half of the students and the vast majority of the PSTs felt not at all or not prepared enough by their previous CCE (school education for students, university education for PSTs), many of the students, who felt well prepared, still reported weaknesses and wished for further improvement of their CCE. Most participants of both samples justified their concerns by either a total lack of opportunities to experience climate change specific learning activities or those, for example, being superficial and not action-oriented. The identified weaknesses in current CCE settings (Figure 6) could therefore counteract the willingness of students and PSTs to engage as change agents. Surprisingly, as we think of university students as well-educated adults, and in this case prospective teachers that should educate their future students about climate change, the results of our study (Figure 4) revealed that CCE in teacher training programs might even fall behind CCE at schools when it comes to the feeling of preparedness of the investigated PSTs and school students.

Our in-depth-analysis provided possible reasons to why climate change might often be dedicated too little time or why the provided information might be too superficial: Some students and PSTs argued that this is the case because of disciplinary boundaries and the issue's cross-curricular character. In addition, previous studies suggested that educators, both at schools and universities, are often confronted with difficult decisions concerning where and for how long the topic can be integrated into their teaching [28,78]. Referring to data concerning Weaknesses of Current CCE (see Section 3.2) and Ho and Seow [78], we identified special curricular limits to CCE in our case: On the one hand, the Austrian school curriculum is organized in a subject-centered way, but climate change is only rarely mentioned in these subject-specific standards [74]. On the other hand, teachers shall organize Education for Sustainable Development (ESD) in an interdisciplinary approach of environmental education [75], which can possibly lead to the experience that "no one devotes themselves directly to the subject, but only talks about it in passing" (SOJÄFE, S, 15 y, f). Because of vague guidelines and referring to students' statements, we assumed that determining CCE as a concrete lesson topic might often be left to the individual teachers. Here, future research should focus on the perspectives of in-service-teachers to further examine this challenge to CCE. In our study, the case of the PSTs' teacher training program seemed quite similar to the school situation, since the investigated PSTs in the field of "biology and environmental education" referred to the curriculum as being broadly based and at the same time excluding climate change (see Section 2.1), which results in a lack of specific courses on the issue, also concerning the didactic preparation of the topic. In the specific context of our study, we therefore suppose that the issue of climate change, because of its interdisciplinary nature, could defy the logic of single disciplines in the Austrian educational system, both at schools and teacher training programs. Changes in curricula or the wish to establish a single subject or university course on climate change (see Figure 6) could therefore be worth discussing on the level of educational policy.

Fortunately, our findings also suggested that individual schools might be already on the way and include CCE despite curricular hindrances, although this may still depend on

the commitment of individual teachers, as suggested by participants in both cohorts (see Section 3.2). The identified example of a "climate club" at schools shows that educational institutions must not only be viewed as slow-changing entities [10], but also as agencies that offer flexibility and creative spaces for innovation, if change is actively pursued. Still, if this change is not to be left to the individual, then, besides curricular changes, teacher training in particular opens the opportunity to make progress and equip PSTs with the competences they need to integrate CCE into their respective school environments and release their potential as change agents, despite existing hindrances [37].

### 4.2. From Schools Promoting Information to Spaces of Transformation

The findings concerning the Perceived Role of Schools and Teachers in Combating Climate Change suggested that schools are most often seen as informing, neutral bodies (see Section 3.1). The following statements exemplify this trend in the data: "[...] school plays an important role in the dissemination of information" (SUFEFE, S, 16 y, f) and PST BEJUJA (PST, 23 y, f) said: "You can inform about things that are totally logical for you but maybe not for the students". These results are not surprising since previous CCE research and education programs have primarily focused on the promotion of content knowledge [41,42]. Concerning this, our data referred to a controversial discussion within CCE research: The students of our sample often argued to be willing to multiply climate change information since, from their perspective, "Being informed is the basis to take action", "It concerns all people, so all should be informed" or "The more people know about what's happening, the more you can accomplish" (VEMANO, see Section 3.1). In addition, many of the PSTs seemed inclined to follow the assumption that spreading information will lead to changes in behavior, as shown in Section 3.2: "Educated/sensitized students will act/choose/shape their lifestyle differently than students who know nothing about climate change" (KADESE, PST, 23 y, f).

From the perspective of science education research, it is undoubted that content knowledge presents one of many prerequisites in order to take action, but at the same time, strengthening knowledge alone is not sufficient to change environmental or pro-climate behaviors or attitudes [45,46]. Although individual students took a reflective stance concerning this: "I don't think it's hard to inform people, I think it's hard for people to do something about it" (FIAPAP, S, 15 y, f), it is interesting that most CCE recipients in our study seemed to see the role of content knowledge as predominantly important to induce behavior change.

At the same time, the results showed that both students and PSTs concluded that their previous CCE did not sufficiently manage to address the question of meaningful, possible courses of action to tackle climate and "actively do something about it" (SOJÄFE, S, 15 y, f), although schools might at least succeed in providing basic information about climate change. Moreover, the findings suggested that students identify significant challenges concerning them multiplying climate change information because of dismissive attitudes by other people such as ignorance, resignation, or denial (see Section 3.1). Other challenges perceived by the students when acting as change agents included specific aims, such as to reach all people, to convince them, or to become active. To help students overcome these challenges, it seems that science educators need to open up the room for students to become equipped with the competences they need to address the socio-political challenges as political actors, instead of limiting CCE to only teaching scientific content knowledge [40,79].

At this point, it has become clear that addressing the questions of practical solutions and the political, ethical, or psychological aspects of climate change as an SSI is important [21,38,40,48,49]. Otto et al. [10] emphasized that education about the causes and consequences of climate change alone cannot trigger sufficient transformative processes towards a climate-neutral transition. Instead, educational institutions, as "living laboratories", must also offer spaces in which climate-friendly lifestyles and commitment are promoted, and thus the principle of sustainability can be learned, consciously realized, and implemented by all actors in educational institutions [10,80]. This understanding of

the role of educational institutions might help to find a more holistic approach to CCE, as many of the investigated participants in our samples seemed to share great willingness to become active on the one hand, but only rarely imagined the role of schools or universities as one doing more than spreading information on the other hand. Fortunately, individual students pointed out: "The school has the task of informing what is happening and what possible solutions there are. In addition, the school community itself must also make a contribution" (DAFESE, S, 16 y, f).

### 4.3. The Affective Dimension of CCE

Concerning the affective dimension of CCE, we identified specific challenges, as our results showed that a large proportion of investigated students exhibited negative feelings about the topic of climate change and future lessons (see Section 3.3). For example, feelings of sorrow, sadness, and guilt were reported by many students. Especially in the students sample, self-referring negative feelings such as shame or guilt were shared: "I have to say that I am a little ashamed, so I do not do more for the environment" (SEDEOK, m, 16 y). At the same time, many students shared mixed feelings concerning future CCE, because they face negative feelings due to the issue itself and also positive feelings such as interest or hope, because "hopefully the opinion of some people will change to the positive, which will lead to the fact that we can stop climate change"" (BEFESE, S, 15 y, f). In addition, a smaller group of students seemed dismissive towards future CCE lessons. This diverse, highly emotional involvement shared by most of the students can pose a specific challenge to teachers. Since affective experiences in CCE can have term effects on learners' engagement with climate change, educators need to actively encounter, instead of subconsciously foster, identified challenges on an affective level, such as youth's experiences of disempowerment, the overwhelm of limited agency, and the generational gap [58]. If teachers do not acquire the capacities to encounter those feelings and needs, students might increasingly feel left alone by older generations and professionals, which could exacerbate the already existing mistrust and generational conflict or the strengthening of disempowering emotions, as Jones and Davison [58] argued. As already mentioned above, it seems that future science education and research have to find strategies on how to deal with diverse climate change awareness groups of students [13], since our findings suggest that quite different but strong emotions are shared concerning this.

This argument is also supported by several other findings of our study indicating (in both cohorts) that students are treated as the primarily affected group of climate change and also as the primarily important target group of CCE. For example, both students and PSTs argued to be willing to multiply climate change information due to the "Importance of young people for (the) future" (Figure 1) or that the role of schools to combat climate change gains importance because teachers "can have an early impact on children's future lifestyles" (MIMÄFE, PST, m, 21 y). Interestingly, the investigated PSTs seemed rather unaffected and perceived climate change as an issue of the future or the younger generation (see Section 3.2). These perceptions do not align with the current scientific evidence [6,81] but might be caused by a different group identity (e.g., teacher-student, older-younger) of the investigated samples. Indeed, climate change impacts will influence people's lives more heavily the younger they are, but in our study the investigated samples differed by only 7 years concerning their median ages (median ages: S = 16 y, PST = 23 y), with the oldest students (18–19 y) in our samples being only slightly younger than the youngest PSTs (20–21 y). Therefore, both sample groups will highly be affected by climate change. Here, we located the risk of further hesitation to implement action-oriented CCE, when climate change and climate protection, including both mitigation and adaptation, continue not to be treated as necessities at the present time by all groups of educational agents [13,80,82]. By framing climate change as a challenge of the present, which needs to be addressed by all actors of society [6,10], climate change educators could help counter those challenges.

Taking the already described negative feelings of students into account and that the mental health of young people worldwide is already impacted by increasing climate change

consequences [83], the question arises how children and teenagers can be supported by professionals in a trusting environment, where they can actively engage in mitigating climate change and learn coping strategies in order to adapt to its consequences and build climate resilience [60,61]. Here, our findings suggested that the investigated PSTs saw the lack of their own capacities as the most dominant challenge to teaching climate change in the future (see Section 3.1). Teacher training programs and future CCE research should therefore primarily focus on fostering competences to counter the psychological challenges of CCE, which is also suggested by previous literature [37,49].

Ultimately, our data suggest that students could be increasingly willing to take on their role as change agents if they find more support by others to do so. Of course, "the world's population" will not live climate-neutral overnight, but the student's statement could reflect the wish to act in a social community instead of feeling bad because of individual climate-damaging behavior. These findings gain importance in light of the previous literature, which suggest that environmental education has been limited to promoting individualistic behavior lifestyle changes [43,84,85]. In this regard, Niebert [40] argued that ESD has to focus on fostering political education and "relieve educators from approaches aiming—usually unsuccessfully—at changes in behaviour" [40] (p. 3). Such an approach could also help to relieve students of their perceived negative feelings of shame or guilt, as reported in this study, and to empower their self-efficacy. Here, schools and educational institutions in general, as social bodies, provide the opportunity to engage different actors in social learning for climate adaptation and, hence, in building societal resilience as a school community in an intergenerational way [86]. Taking action as a school community, including students, parents, as well as teachers, could also help students to overcome identified mistrust in others and unfold their transformative potential as change agents, when they can experience schools as learning environments, where climate action is supported and "role models" (see Section 3.1) can be found.

*4.4. Limitations of the Study*

Due to the explorative approach and setting of the study, the sample size of the investigated cohorts differed (see Section 2.1). In our analysis, we focused on the secondary school students' perspectives and used the data of the PSTs as a complementary perspective to identify systemic challenges to CCE. We believe, however, that this does not pose a problem, as we did not aim for a strict quantitative comparison between the two samples, but rather for a qualitative, exploratory, and descriptive investigation. By doing so, we aimed to investigate our object of research, namely the participants' perspectives on CCE, in its depth. Hereby, we think that not only the most common shared perspectives are worthy to investigate, but also perspectives that gain their relevance from their specific context. Hereby, we think that our case study thus reflects a small part of everyday school life, where many times more school students meet a smaller group of teachers. As it is the case with qualitative research design settings, we think that the sample of 92 possible change agents in total still delivers valuable findings.

Next to that, we collected students' and PSTs' subjective and self-reported perceptions. Eventually, PSTs might have given socially desirable answers to maintain their professional self-image. Therefore, the results of this study have to be interpreted against the background of these limitations. In the case of the students sample, we think that this is rather not the case, since our data evoked the assumption that students answered honestly and did not feel pressured since they participated in the workshops voluntarily, whereas the PSTs answered the questionnaire within a university context.

Since we chose to investigate the perspectives of future biology teachers, our sample was characterized by a very specific context and gave, therefore, limited insights into PSTs' perspectives on CCE in general. However, in our specific case study setting, we wanted to concentrate on one of two identified subject strands (Biology and Geography) at the teacher training program at the university of Vienna, which, according to their subject curricula, are the most determined to include CCE. However, for future research, it might be worth

investigating the CCE perspectives of PSTs also from other subjects, which are less inclined to prepare PSTs for teaching climate change in the future.

*4.5. Implications for Researchers, Educators, and Policy Makers*

This study investigated the perspectives of two major target groups of CCE, namely secondary school students and PSTs. We found that students and PSTs are not sufficiently supported by their respective educational institutions to exercise their transformative potential as change agents due to reasons at an individual but also systemic level of their respective educational systems. Furthermore, the results shed light on the importance to create opportunities in CCE settings to develop climate resilience. We suggest the following recommendations to be taken into account by researchers, educators, as well as policy makers in the field of CCE:

1.  The results from this study suggest developing CCE settings that take into account different learner groups concerning their willingness and affective involvement towards climate change and climate action: Our findings underlined the emotionalized and polarized discourse around climate change as an SSI and its high learner involvement. In order to avoid that individual, particularly engaged students feel overburdened and those who are hostile to the topic do not feel understood, we recommend considering such different types of climate awareness among students when designing educational programs.

2.  We suggest restructuring curricula at schools and providing clear guidelines on how to integrate the topic in different subject lessons: Our data indicate that the topic of climate change escapes the Austrian discipline-centered education system due to its strong interdisciplinarity, as it cannot simply be pigeonholed. A stronger curricular anchoring could counteract the possibly insufficient treatment of the topic in schools, as well as in teacher training programs, and support potential lone warriors who have so far treated the topic in extraordinary educational settings ("climate club"). At the same time, precisely because of its interdisciplinary facets, the topic offers the opportunity to take a holistic approach to education.

3.  We suggest addressing the psychological dimension of CCE and students affective involvement: Our data indicated that students experience negative emotions on different levels due to the climate crisis, which are also "carried" into the classroom. To support students' mental health, we therefore recommend addressing the psychological dimension of the issue and creating sensitive learning environments where students can confide in their peers.

4.  The results suggest anchoring CCE in teacher training programs: As climate change mitigation and adaptation towards its consequences is one of the main tasks of the 21st century, educational institutions have a great responsibility in the climate-neutral transformation. Therefore teacher training programs must address the question of how to professionally train future teachers in this field.

5.  We recommend providing PSTs with interdisciplinary content knowledge, topic-specific pedagogical content knowledge, and psychological knowledge: Since scientific content knowledge is not enough to teach the topic in an action-oriented way and as a Socio Scientific Issue, teacher education programs need to broaden their horizons and create CCE opportunities for PSTs to gain competences. The topic of climate change is characterized by issue-specific challenges, such as its complexity, interdisciplinarity, high learner-involvement, and psychological challenges, so teachers need a basic knowledge to deal with them.

6.  Climate education needs to become community-oriented. We suggest providing PSTs with strategic knowledge on how to integrate action-oriented, community-led learning environments at schools to foster climate resilience: CCE cannot unfold its transformative potential when it remains limited to traditional educational settings. Instead, schools and universities alike should offer unique opportunities to include

various societal actors and bring them together to pursue the common goal of shaping a livable future.

## 5. Conclusions

Previous research suggests that education can play a pivotal role in transforming our societies in a climate-just way by viewing students and their (future) teachers as agents of change. However, research also demonstrates that educational institutions, such as universities and schools, face challenges equipping their learners to take on this role. To shed light on these challenges in CCE, we used a case study approach to examine two key perspectives, those of students and PSTs. Our findings indicated that both students and their prospective teachers are ready for change but feel inadequately prepared for their role as possible change agents. Moreover, challenges in CCE also lie at a systemic level, within the educational institution itself, and some are even linked to national educational policies and curricula. Furthermore, the results underpin the importance of integrating the affective dimension on climate change into CCE, where feelings of disempowerment, climate anxiety, or intergenerational mistrust are addressed and hope is given to develop actionable climate resilience. Because effective CCE relies on students and their future teachers, we concluded that CCE should discuss these challenges to be most supportive. To accomplish this, we recommend the design, empirical evaluation, and implementation of CCE settings that are responsive to the needs of students and PSTs. In addition, a review and reassessment of educational frameworks and policies can be seen as essential to assist future teachers and their students with the know-how of how to create transformative learning environments. We believe that such education can ignite important sparks for transformative change by enabling education institutions to create a climate of change.

**Institutional Review Board Statement:** For this study, ethical approval was not required. The study was conducted with secondary level students and PSTs. Both samples were informed in advance that participation is voluntarily and that data collection takes place anonymously. According to Austrian law, approval of an ethics committee was not necessary as this study did not involve patients, was non-invasive, and participation was voluntary and anonymous.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The data presented in this study are available upon request from the corresponding authors.

## Appendix A. Coding Guideline

Six main categories were established, referring to the items of the questionnaire. The sub-categories of each main category are presented below. In the case of a great number of sub-categories per main category, clusters were used to further structure the identified sub-categories, which are highlighted grey and specified in capital letters. Statements got coded into several categories if they applied to more than one category. Anchor examples are cited from the original manuscripts and can be requested. The frequency of appearance refers to the number of participants (S/PSTs) who stated the respective sub-categories and/or sub-categories in clusters.

**Table A1.** Coding guideline including anchor items and frequency of identified categories in both samples.

| ITEM 1: Believed Reasons for Being a Change Agent | | | |
| --- | --- | --- | --- |
| **Sub-Categories** | **Anchor Examples** | **S** | **PST** |
| **Positive Stance** | | **59** | **18** |
| Being informed is the basis to take action | [...] by spreading this message more and more people also become active [...] (KAJAMA, pos. 11) | 25 | 6 |
| It concerns all people, so all should be informed | Climate change affects us all, so everyone should be able to understand the scientific consensus and the underlying data. (BAJUAU, pos. 5) | 23 | 4 |
| Idea of multiplication | The more people know about what's happening, the more you can accomplish. (VEMANO, pos. 11) | 16 | 0 |
| Feeling of own responsibility | Because if I don´t, then who knows what the future holds? (EMJADE, pos. 11) | 15 | 0 |
| To raise awareness | The more who know about it, the more who can become aware of it (MAOPNO, pos. 11) | 6 | 7 |
| People lack knowledge or awareness | Some people are unaware and/or even in denial about climate change and its consequences. (HEDEJU, pos. 11) | 10 | 1 |
| Importance of the issue | Because the topic of climate change is very important. (HEJUAU, pos. 5) | 5 | 6 |
| Importance of young people for future | Climate is important for everyone, and it must be especially important for us, because we live as young generation and we must do more than everyone for our climate. We have to think like this: if we don't do something for our climate now, then one day we will be to blame (MADEAU, pos. 11) | 5 | 6 |
| Responsibility of schools and teachers | I find that I do not have alone the responsibility to inform my fellow men about the climate change, because this should already take place in schools etc... ... should take place! (SUFEFE, pos. 11) | 1 | 6 |
| To clear the facts | To clarify misunderstandings. (MEAUAU, pos. 11). | 2 | 4 |
| To address the topic's political dimension | Climate change is one of the central problems—or perhaps even the central problem—of our society today. Thus, it is not only interesting from a biological point of view and thus relevant for my lessons, but also from a socio-political point of view. (EVNOMA, item 5) | 0 | 2 |
| Topic is well suited for project lessons | Suitable for project-oriented teaching. (ELJUMA, item 5) | 0 | 1 |
| **Critical Stance** | | **17** | **1** |
| People are already informed | They already know about climate change. (NUDEJÄ, pos. 11) | 9 | 0 |
| Not my responsibility | Because I do not see it as my personal task to inform others. (SADEJU, pos. 11) | 3 | 0 |
| Lack of opportunities | I myself am interested in climate change, but it is not often a topic of conversation for me and my friends. (KAJUJA, pos. 11) | 3 | 0 |
| Responsibility of government or media | In my opinion, the government should take more initiative. (SNDEOK, pos. 11) | 1 | 1 |
| Climate change is not important | People should know that $CO_2$ emission is not a regulator of temperature rise and that it is not clear now how the climate works at all. Fossil fuels are important and enable us to live modern life. Don't cry! Your generations before us couldn't help it. They were damaged. More important things to do, e.g., you don't have to starve every day. (LIAUJU, item 11) | 1 | 0 |

**Table A1.** *Cont.*

| ITEM 2: Challenges in Multiplying Climate Change Information | | | |
|---|---|---|---|
| Sub-Categories | Anchor Examples | S | PST |
| **Inherent in Others** | | **28** | **1** |
| Doubt or denial | There are many climate deniers who do not accept the facts, so it is difficult to have a discussion with these people. (EVFESE, pos. 15) | 9 | 0 |
| Ignorance or narrow-mindedness | With the narrow-mindedness of many fellow human beings. (ANMAOK, pos. 15) | 7 | 0 |
| Lack of interest | Many don't care; everyone believes that no one takes it seriously anyway. (BEAPJU, pos. 14) | 7 | 0 |
| Lack of self-efficacy or resignation | My fellow men take this too seldom seriously, because they are of the opinion that they cannot change anything about climate change anyway. (VEMANO, pos. 15) | 5 | 0 |
| Laziness and status quo | People are generally too lazy to be active. (AMDEAP, pos. 15) | 3 | 0 |
| Differing prior knowledge | Finding the right time to say something they don't know yet. (AMDEAP, pos. 15) | 2 | 1 |
| **Aims** | | **20** | **8** |
| To convince people | Influencing the opinion of fellow human beings is quite difficult, I think. (KAJUJA, pos. 15) | 11 | 0 |
| Possible courses of action | I think it is very difficult to talk about it without students feeling personally attacked. To create an awareness for climate change and to show how one can act against it in everyday life. (SAJÄDE, pos. 9) | 4 | 3 |
| Becoming active | They must overcome to spend force to take action to prevent climate change. (MADEMÄ, pos. 15) | 5 | 1 |
| To arouse interest | To make this subject student friendly and give them knowledge that they are really interested in. (BEJUJA, pos. 9) | 1 | 3 |
| To reach all people | That you first get the opportunity to be heard by everyone. (DAOKJÄ, pos. 15) | 3 | 1 |
| **Own Capacities** | | **15** | **10** |
| Lack of own knowledge | I think that I am not yet perfectly familiar with the subject. Furthermore, it is difficult to find the right access and entry for it. (ROAPMA, pos. 9) | 13 | 3 |
| Didactic preparation of the topic | Making this topic student friendly. (BEJUJA, pos. 9) | 1 | 7 |
| Own will and engagement to inform others | It requires a lot of self-organization and additional work for preparation, breaking up old contents/structures. (MAJUSE, pos. 9) | 1 | 2 |
| **Inherent in the Issue Itself** | | **5** | **8** |
| Urgency and importance | The challenge I see is that I don't know how to convey to the students the urgency of taking action NOW. (ANOKSE, pos. 9) | 4 | 2 |
| Emotionalization or polarization of the topic | Strongly emotionalized topic. (BAJUAU, pos. 9) | 0 | 5 |
| Complexity and multi-layered nature of the topic | Very complex topic with many facets (environmental science and social science). (ELJUMA, pos. 9) | 1 | 2 |

**Table A1.** *Cont.*

| ITEM 2: Challenges in Multiplying Climate Change Information | | | |
|---|---|---|---|
| Sub-Categories | Anchor Examples | S | PST |
| **Inherent in Others** | | **28** | **1** |
| **Risks** | | 6 | 3 |
| Annoying others | Not to get on their nerves. MODEMA, pos. 26) | 5 | - |
| Troubles with parents | Influence of parents and complaints (e.g., if you explain to the pupils that a vegan diet is better for the climate, they then refuse meat at home, and the parents complain about it). (MAJUOK, pos. 9) | 0 | 3 |
| Political influence on students | Possible political influence on the students. (MEAUAU, pos. 14) | 1 | 0 |
| **General Conditions** | | 2 | 2 |
| Too little time in future lessons | | 0 | 2 |
| Lack of opportunity | People do not talk about this issue so often. (SUAUNO, pos. 15) | 2 | 0 |
| **Not Specified** | | 9 | 0 |
| No challenges | For me, there are no challenges in informing my fellow human beings about the topic of climate change. (ELNOAP, pos. 15) | 6 | 0 |
| Could not be assigned | - | 5 | 0 |
| Not specified | - | 4 | 0 |
| ITEM 3: Role of Schools and Teachers in Mitigating Climate Change | | | |
| Sub-Categories<br>Positive Stance | Anchor Examples | S<br>68 | PST<br>17 |
| Schools and teachers should inform and educate about CC | I think school plays a big role because students get most of their information from there (SOJÄFE, pos. 12) | 31 | 11 |
| Schools and teachers have great relevance in combatting climate change | A big role because children need to learn how to deal well with the world. (AMDEAP, pos. 12) | 16 | 9 |
| Schools and teachers play a multiplicative role | I think a very big role, because very many people are influenced by teachers. (SAJÄDE, pos. 6) | 13 | 4 |
| Schools and teachers should act as role models for climate action | In addition, the school community itself must also make a contribution. (DAFESE, pos. 12) | 10 | 2 |
| Teachers can motivate or have an influence on students | They can have an early impact on children's future lifestyles. (MIMÄFE, pos. 6) | 0 | 8 |
| Students are the future | Pupils belong to the group that will be very important in the future. (EVFESE, pos. 12) | 4 | 1 |
| School should draw attention to CC and climate action | The school should draw attention to climate change. (ELDEFE, pos. 12) | 3 | 1 |
| **Critical Stance** | | 8 | 3 |
| Schools are not relevant in combatting climate change | I don't think the school takes a big role, rather the media. (KAMÄAP, pos. 12) | 7 | 1 |
| Scope of teachers is limited | We can only inform responsibly, we will not change the basic problem (capitalism, expansionism). (BAJUAU, pos. 6) | 0 | 3 |
| School should not force people to climate-friendly behavior | However, it should not force anyone to behave in a climate-friendly manner. (ELDEFE, pos. 12) | 1 | 0 |
| **Further Categories** | | | |
| Could not be assigned | - | 1 | 1 |
| Not specified | - | 1 | 0 |

**Table A1.** *Cont.*

| ITEM 4: Preparedness to Multiply Climate Change Information | | | |
|---|---|---|---|
| **Sub-Categories** | **Anchor Examples** | **S** | **PST** |
| Not at all prepared | No, because in regular classes the topic is hardly or not at all dealt with. (LJJANO, pos. 13) | 15 | 10 |
| Not enough prepared | No, not enough. We are prepared a little bit, but not much. (AMJUMÄ, pos. 13) | 21 | 6 |
| Partially prepared | Yes, partially. Sufficient to have a small discussion, but nothing more. (EVFESE, pos. 13) | 14 | 2 |
| Well prepared through education | Yes, because, at the moment, I have noticed that we are doing much more than before. Now we start projects or go to demonstrations. (FAJUAU, pos. 13) | 29 | 0 |
| Preparedness dependent from individual teachers | No, so far. Apart from a lecture on animals, in which the prof refers to insect extinction from time to time. (MAJUSE, pos. 7) | 7 | 6 |
| Preparedness lies in individual responsibility | For more information about climate change, I have to do my own research and ask; the school only explains what climate change is, nothing more. (KAJUJA, pos. 13) | 3 | 4 |
| Not specified | - | 2 | 0 |
| ITEM 5: Strengths and Weaknesses of Current CCE | | | |
| **Weaknesses** | **Anchor Examples** | **S** | **PST** |
| Climate change is dedicated too little time | Yes, on the whole, but in detail and comprehensively rather not. We are informed in geo, bio, physics, and chemistry about the greenhouse effect and its consequences, but I don't feel really informed. (NAJUDE, pos. 13) | 30 | 15 |
| Practical examples, application, and solutions are missing | I already receive some information, but we are often severely thwarted when it comes to active participation. (ANMAOK, pos. 14) | 15 | 5 |
| Provided information on climate change is too superficial | Only partially, because only a limited amount of information is passed on to the students. For a comprehensive knowledge, more time and greater interest is important. (ELDEFE, pos. 13) | 11 | 4 |
| Climate change is taught only in few subject(s) | We went through it in geography, but much too short in my opinion. At least we did a workshop on it, but most people don't take it seriously and just see it as fun. (BEFESE, pos. 13) | 13 | 1 |
| Participation in Fridays for Future strikes got prohibited | For example, in my school we are not allowed to participate in Fridays For Future, and the lessons are not excused. I think it's important for students to be able to demonstrate and speak their minds. (ALJAMA, pos. 14) | 13 | 0 |
| Preparedness lies in individual responsibility | So far, climate change has only been mentioned in passing in the curriculum. This means that every teacher is responsible for how and how long he or she treats the topic in class. (KADESE, pos. 7) | 3 | 4 |
| School is not acting as a role model | Only drinks in plastic bottles are sold; the school heats too much in winter; the school could change a lot. (BEAPJU, pos. 12) | 5 | 1 |
| Didactic preparation of the topic is not taught | So far I have not been shown how to relate climate change to a school class. (SAJÄDE, pos. 8) | - | 2 |
| Teachers are too little informed or experts not available | No. Why? Because too few experts in this field teach at the University of Vienna (in the teaching profession)! (HEMASE, pos. 7) | 1 | 1 |
| Wish for a separate school subject or course on the issue of climate change | "One would need, e.g., own subject." (JOJUAP, pos. 14) | 1 | 1 |
| Counteracting of individual teachers or school principals | Director and professor. (IRMAJU, pos. 14) | 1 | - |

**Table A1.** *Cont.*

| | Anchor Examples | S | PST |
|---|---|---|---|
| **ITEM 5: Strengths and Weaknesses of Current CCE** | | | |
| **Weaknesses** | | | |
| Lessons on climate change are boring | Weaknesses: partly boring lessons > attention of students decreases. (SUAUNO, pos. 14) | 1 | - |
| Lack of financial resources | No financial resources. (WIJUNO, pos. 14) | 1 | - |
| **Strengths** | | | |
| School clearly informs about the subject | To a certain extent, because we have the climate club and we've also talked about it a lot in class. (LEAPAP, pos. 13) | 33 | - |
| School informs to some degree | Somewhat; I know enough about climate change but not how to make it clear to others. (BROKMÄ, pos. 13) | 17 | - |
| Practical examples or interactive elements are included | Yes, because at the moment I have noticed that we are doing much more than before. Now we start projects or go to demonstrations. (FAJUAU, pos. 13) | 18 | - |
| High interest from students | There are young minds in school. If you teach the students from the beginning and tell them what's going on now, they can contribute to the future. Do something about it. Even now, too. (if you change their mindsets). (NAMAOK, pos. 13) | 2 | - |
| Participation of protests | Partly, we were in a climate strike once, and then we started a climate club ourselves, where we are more involved with this issue and invite others there. (KEMÄJU, pos. 13) | 4 | - |
| Scientific processing of the topic | Scientific treatment of the subject. (MEAUAU, pos. 14) | 1 | - |
| Biology teacher program is broadly based | The study program is very broad. However, climate change is not explicitly mentioned in one of the major courses, so there is a lot of initiative to work through the topic for students. (ANNOAU, pos. 7) | - | 7 |
| Not specified | - | 3 | 5 |
| Climate change is taught in many subjects | Actually, it does and in many subjects like Geo or English. (REMÄAP, pos. 13) | 7 | - |
| **ITEM 6: Affective Dimension of CCE** | | | |
| **Sub-Categories** | **Anchor Examples** | **S** | **PST** |
| **Positive Emotions** | | 31 | 14 |
| Joy | Joy; it is important to talk about it and would like to have it in class more often. (BAJUMÄ, pos. 16) | 12 | 5 |
| Interest | Teaching about climate change creates interest and determination in me. (SEDEOK, pos. 16) | 12 | 3 |
| Motivation or willingness-to-act | Actually a positive one, because I think I can make a difference. (BEJUJA, pos. 10) | 4 | 6 |
| Curiosity | At the moment, I'm still a little nervous, because I'm not yet well prepared for it. But also great interest and curiosity. I am aware that it is an important point in biology lessons, regardless of age. (SAMAFE, pos. 10) | 3 | 3 |
| Determination | The determination to work against climate change. (SADEJU, pos. 16) | 5 | 0 |
| Excitement | Excitement (SOJÄFE, pos. 16) | 3 | 1 |
| Hope | The feeling that all is not lost (hope) and that everyone can contribute something to it. (URAPDE, pos. 16) | 3 | 0 |
| Satisfaction | Satisfaction, because we are finally talking about it (BEFESE, pos. 16) | 3 | 0 |
| Responsibility | Anticipation and sense of responsibility. (ROMÄJU, pos. 10) | 0 | 3 |
| Pride | Pride. (FAJUAU, pos. 16) | 2 | 0 |

**Table A1.** *Cont.*

| ITEM 6: Affective Dimension of CCE | | | |
|---|---|---|---|
| **Sub-Categories** **Positive Emotions** | **Anchor Examples** | **S** 31 | **PST** 14 |
| Anticipation | The anticipation of finally being able to pass on something that really has added value. We can actively participate in the improvement and animate other people to get involved in the future. (MIMÄFE, pos. 10) | 0 | 2 |
| Attentiveness | Attentive. (SAAUSE, pos. 16) | 1 | 0 |
| Cohesion | Strength/cohesion. (MAOPNO, item 16) | 1 | 0 |
| **Negative Emotions** | | 37 | 6 |
| Sorrow | Worries me because it is difficult to change anything. (SUJÄJU, pos. 16) | 9 | 0 |
| Sadness | It is sad when you see how nature perishes or the animals die because of us. The pictures make a lot of things. (SEOKOK, pos. 16) | 8 | 0 |
| Guilt | I always get feelings of guilt and feel very bad. (NAJÄDE, pos. 16) | 6 | 0 |
| Anger | | 6 | 0 |
| Nervousness | Nervousness, as I might steer students in the "wrong" direction if I bore them with my climate change lessons. (ROAPMA, pos. 10) | 2 | 3 |
| Fear | Anxious. (IRMAJU, pos. 16) | 5 | 0 |
| Fright | Shocking to learn about our situation. (SNDEOK, pos. 16) | 3 | 0 |
| Rage | Rage. (EVFESE, pos. 16) | 3 | 0 |
| Disappointment | It is just a pity that many people are not aware of what is happening on our planet right now. (ÜMSEJU, pos. 16) | 3 | 0 |
| Insecurity | A little insecurity about being up to the task; the positive feeling of being able to take responsibility and actively contribute to raising awareness. (EVNOMA, pos. 10) | 0 | 3 |
| Awe | On the one hand, joy that I can actively make a difference and encourage others to do something. On the other hand, respect for the so important task. (MAJUSE, pos. 10) | 0 | 3 |
| Confusion | Partially confused. (BROKMÄ, item 16) | 2 | 0 |
| Shame | Teaching about climate change creates interest and determination in me. Unfortunately, I have to say that I am a little ashamed, so I do not do more for the environment. (SEDEOK, pos. 16) | 2 | 0 |
| Stress | I always get feelings of guilt and feel very bad. (NAJÄDE, pos. 16) | 2 | 0 |
| Frustration | Frustration because we hear a lot of nonsense and unimportant things. (NUNOAP, item 16) | 1 | 0 |
| Pessimist | Somewhat pessimistic thought about the future. (SNDEOK, pos. 16) | 1 | 0 |
| Helplessness | You can't do that much about it; helpless. (SIJUJU, pos. 16). | 1 | 0 |
| Pressure | Pressure. (SAJÄDE, pos. 10) | 0 | 1 |
| Uselessness | Uselessness. (MOJUDE, pos. 16) | 1 | 0 |
| Disappointment | I am very disappointed in mankind. Being so reckless with the earth should not be the case in 2019. Of course, I am also disappointed in myself for the way I treat the environment, but I would be willing to change/improve many habits in my life if everyone else or a large part of the world's population would do the same. (VEMANO, pos. 16) | 1 | 0 |

**Table A1.** *Cont.*

| ITEM 6: Affective Dimension of CCE | | | |
|---|---|---|---|
| **Sub-Categories**<br>**Positive Emotions** | **Anchor Examples** | **S**<br>31 | **PST**<br>14 |
| **Dismissive** | | 11 | 0 |
| Oversaturated | I wouldn´t be that interested, because I already have roughly 10 classes, and another one would not be ideal for us students. (EMJADE, pos. 16) | 6 | 0 |
| Boredom | It's kind of boring by now. (AMJUMÄ, pos. 16) | 4 | 0 |
| Indifference | Is bad but I don't care (indifference). (GEOCJÄ, pos. 16) | 1 | 0 |
| **Further Feelings** | - | 13 | 2 |
| No emotions | At this moment, rather none. (FIAPAP, pos. 16) | 7 | 0 |
| Mixed feelings | Sometimes very interested but sometimes not. (REMÄAP, pos. 16) | 2 | 2 |
| Surprised | Surprised. (REMÄAP, pos. 16) | 2 | 0 |
| Thoughtful | Thoughtfulness. (DAFESE, item 16) | 1 | 0 |
| Not specified | - | 4 | 1 |

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