Fostering teachers as sustainability and climate change educators through understanding of teachers' self-efficacy beliefs

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This is a mixed-methods case study aiming to understand teachers` self-efficacy beliefs for sustainability education in the context of climate change education. Therefore, we studied teachers` self-efficacy beliefs from their own perspective as well as the connection between self-efficacy and related concepts, perceived content knowledge (pCK) and perceived pedagogical content knowledge (pPCK). Twenty-two teachers from 18 countries participating on a climate change education professional development camp answered to a questionnaire, and 19 of them were interviewed using semi-structured interviews. The results of this study show that, according to the interviews, the studied teachers have willingness to continuous learn and develop their sustainability teaching. They have beliefs not only about sustainability education but also about themselves as sustainability educators, which is something that the future instruments on teachers` beliefs should acknowledge. The questionnaire results however showed that teachers had the lowest self-efficacy beliefs on supporting students` actions for sustainability. Teachers` pCK and their pPCK were shown to correlate with their self-efficacy, especially with items related to action. In conclusion, teacher education could focus on supporting teachers pCK and pPCK to develop teachers` action-related self-efficacy beliefs thus supporting students to act for sustainability.

Keywords: sustainability education, climate change education, self-efficacy beliefs, teacher education, mixed-methods

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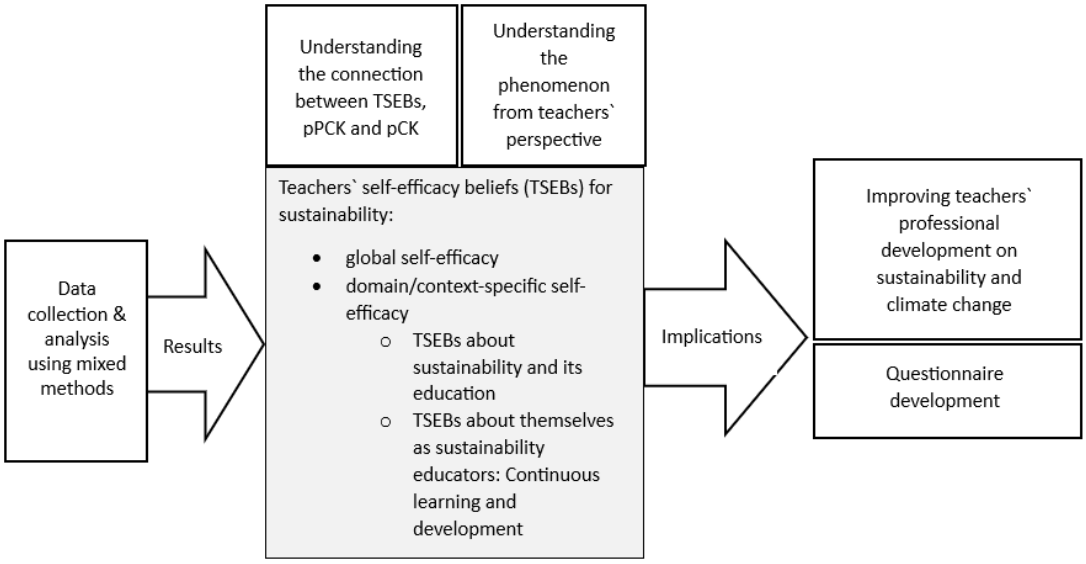

1 Introduction

Sustainability and its education[1] are core development areas in today`s curricula worldwide. In particular, climate change education is a key element responding to climate change (UNESCO, 2019), and thus also related practices have been studied recently (Monroe et al., 2019). In this article, we specifically focus on sustainability and climate change education *for teachers*, because teachers have an important role in educating the future generations and have shown to express valuable insight on improving climate change education in schools (Rushton, Dunlop & Atkinson, 2024).

However, teachers lack both theoretical and pedagogical knowledge of sustainability (Burmeister et al., 2013). Knowledge alone is, however not enough if it does not lead to action. If the teacher knows facts about the climate change and does not act upon them – teach the students about the climate change or support the students to act themselves, the teachers` knowledge does not make much of an impact. Thus, teachers should have willingness and encouragement to act (Almers, 2013). This willingness to act is in many cases called self-efficacy, also studied within sustainability education (Malandrakis et al., 2019). Teachers` active role is a key component in supporting teachers` professional development (Imants & Van der Wal, 2020), and needs to be studied in detail also in the context of sustainability and climate change education. This is because professional development programs are likely to influence on teaching (Desimone et al., 2002) if done properly, and targeting i.e. on key competencies of sustainability and enabling teachers to become sustainability leaders. (Redman et al., 2018). Teachers have also shown to have valuable ideas on how to develop climate change education (Sihvonen et al., 2023; Rushton, Dunlop & Atkinson, 2024). However, not all teacher education programs have been able support teachers in their sustainability teaching abilities. Dahl (2019) found that teacher students felt less confident to teach sustainability than handle other aspects related to their profession.

This raises a question on how to support teachers` self-efficacy. Successful attempts have been made to support teachers` self-efficacy through enhancing teachers` content knowledge (Swackhamer et al., 2019), and connection between pre-service teachers` content knowledge and their self-efficacy beliefs have reported to exist in the context of sustainability education (Nousheen, Zia & Waseem, 2022). During

[1] Malandrakis et al., (2019) has used the term education for sustainable development, and no clear consensus exist whether the term `sustainability education` or `education for sustainable development` or some other variety of those terms, should be used (Herranen et al., 2020). In this article, we use “sustainability education” mainly because “for” is problematic as we do not yet know what a sustainable future looks like (Wals & Jickling, 2002).

teaching career, teachers` knowledge of content and pedagogy, as well as self-efficacy might however change, and this is why we were interested to study teachers` self-efficacy beliefs (TSEBs from now on) on sustainability education, and its relation to teachers` perceived knowledge on sustainability. In previous studies on teachers` sustainability teaching (such as by Nousheen, Zia & Waseem, 2022, and Borg et. al., 2012) studies were survey-based. To shed more light on the nature of teachers` efficacy beliefs, we designed a mixed-methods case study. The studied case is an international climate change education professional development camp organized by LUMA Centre Finland (Teachers` Climate Change Forum Summer Camp, 2020). The mixed-methods approach included an existing questionnaire about sustainability education (Malandrakis et al., 2019) and a follow-up semi-structured interview. As a theoretical framework we use PCK (pedagogical content knowledge) because teachers` beliefs can be understood as a component of PCK. More specifically, this study follows the definition by Malandrakis et al., (2019) separating pedagogical content knowledge (PCK) form perceived pedagogical content knowledge (pPCK) and content knowledge (CK) form perceived content knowledge (pCK) because teachers` perceptions were measured rather than actual pedagogical practices or knowledge.

Research questions of this study are:

1. How are the studied teachers` TSEBs, and related concepts pPCK and pCK?
   (1a) In which areas do the studied teachers feel the most confident?
   (1b) How are TSEBs connected to pPCK and pCK in sustainability education in climate change education professional development camp?
2. What are TSEBs on sustainability education as a phenomenon?

The first research question is studied using a questionnaire (Malandrakis et al., 2019). The second research question is studied using interviews analysed by grounded theory to understand how the teachers describe what teachers` self-efficacy on sustainability education is. Next, we frame the study introducing teachers` self-efficacy and its connection to PCK.

2 Teachers`self-efficacy beliefs and sustainability education

In general, self-efficacy describes how teachers view their own actions and conditions for their actions (Bandura, 1977). It contains a view of a person`s:

- *actions successfully* on the situation at hand

- *efforts* to accomplish something
- *actions in challenging* situations (Bandura, 1977)

For teachers, particularly, self-efficacy beliefs (TSEBs) are those that they have about their teaching abilities (Gavora, 2010), and describe how much effort they put into their teaching (Tschannen-Moran et al., 1998). Previous research shows that TSEBs are associated with teaching and learning, such as with teachers` job-satisfaction (Zee & Koomen, 2016). Teachers however need support in their self-efficacy, especially during curriculum reforms (Gordon et al., 2023).

Literature has also used a concept *teacher efficacy* along with self-efficacy, but we use self-efficacy in this study because teacher efficacy instruments have traditionally been used when studying teacher efficacy in relation to students` academic achievement, which is not the focus of this study (Tschannen-Moran et al., 1998).

Self-efficacy and teacher efficacy have been measured using various scales (Tschannen-Moran & Hoy, 2001), also in the context of sustainability education (Gan & Gal, 2018; Malandrakis et al., 2019). The scales reflect either the Rotter`s social learning theory or Bandura`s social cognitive theory (Tschannen-Moran & Hoy, 2001), as well as the assumed specificity of efficacy, global self-efficacy and domain/context-specific self-efficacy (Zee & Koomen, 2016).

The role and effect of pedagogical and content knowledge in TSEBs is unclear what comes to sustainability education. Pre-service teachers have reported that increase of knowledge of understanding of sustainability affected most to their TSEBs for sustainability education (Evans et al., 2016). On the other hand, when an innovative professional development model was used, teachers were shown to benefit from concentrating especially on self-efficacy and pedagogical content knowledge on climate change (Li et al., 2019).

TSEBs for sustainability education has been studied mostly quantitatively (Malandrakis et al., 2019). However, qualitative approaches could be used to deepen the understanding of different aspects of TSEBs, especially the role of domain-specific (here sustainability education) self-efficacy. To understand how TSEBs affect teaching, the consensus model of PCK (Kind, 2015) can be considered as a useful framework, and thus used in this study. In a consensus model of PCK (Kind, 2015), teachers` beliefs, such as TSEBs, are seen to affect to their classroom practices, such as to their personal PCK. This is because teachers' knowledge is filtered through their beliefs (Fives & Buehl, 2012). In the model, content knowledge is seen as one component of pedagogical content knowledge. Because we have measured teachers` perceptions

in this study, rather than their actual pedagogical practices or knowledge, this study follows the definition by Malandrakis et al., (2019) separating pedagogical content knowledge (PCK) form perceived pedagogical content knowledge (pPCK) and content knowledge (CK) form perceived content knowledge (pCK). The questionnaire by Malandrakis et al. (2019) was chosen at it included a vast number of aspects related to teachers` content knowledge, pedagogical practices, and their self-efficacy related to sustainability in 55 items. Since then, Sinakou et al. (2021) have published a holistic instrument to measure the connection between teacher beliefs and practices related to sustainability education.

To find out how to effectively support teachers` sustainability and climate change teaching, there is a need for a more detailed study on the teachers` self-efficacy beliefs. Therefore, qualitative approaches are beneficial. How teachers describe their teaching, is not clearly reflected in their survey responses. This is why a mixed-methods approach was chosen for this study.

3 Materials and methods

This is a mixed-methods case study with a simultaneous data collection and analysis design (Flick, 2018). As a quantitative part of the data analysis, we used a questionnaire (based on 7-point Likert scale by Malandrakis et al., 2019), from which correlations using Spearman`s correlation coefficients were counted between the scale components. Grounded theory was used as a qualitative part, the data for which was gathered using semi-structured interviews. Both quantitative and qualitative part were necessary because the quantitative part, the questionnaire, aimed to measure teachers` level of perceived level of confidence and the connection between TSEBs, pPCK and pCK, and qualitative part, the interview aimed to capture teachers` beliefs in more detail. An interview has the potential to reveal aspects not included in the questionnaire, but analysing the questionnaire results, connections between aspects under interest are possible to measure quantitatively.

Twenty-two teachers from 18 countries and from diverse backgrounds (in terms of gender, education, teaching level), who participated on a climate change education camp answered the questionnaire before camp, and nineteen of them agreed to be interviewed during camp. The camp was part of a course “Teachers´ climate change forum”. The first part of the course was organized as online MOOC course. However, the MOOC was not a prerequisite for the camp. Nor was participation to the camp obligatory for those registered to the MOOC. Thus, camp and the MOOC were

connected but only some of the teachers participated in the camp as well as completed the MOOC. The camp was organized by the Science Education Centre (part of Luma Centre Finland) in collaboration with INAR in Hyytiälä in summer 2019. The camp included research presentations about ongoing research projects, getting to know the Hyytiälä forest station on cite, and workshops on climate change teaching, such as the use of drama pedagogy.

Mixed-method approach was chosen to describe and understand the case under study (Stake, 1995). Followed by simultaneous data collection and analysis design, qualitative and quantitative data was collected at approximately the same time, and also analysed at the same time (see Figure 1). Figure 1 also illustrates the connection between the research aim and questions.

Quantitative and qualitative stages both contributed to the research aim. Both the interviews and the questionnaire were used to understand the phenomenon, and questionnaire was also used to give some guidance to the interviews (Flick, 2018). Both components also finally contributed to the implications of the study, to improve sustainability education and to give suggestions to instrument development.

The stages of the study are also included in Figure 1. First, data was collected through a questionnaire followed by teacher interviews. Then, questionnaire and interview data were analysed separately. Finally, results and implications were obtained using both quantitative and qualitative data to answer the research questions and to achieve the aim of the research.

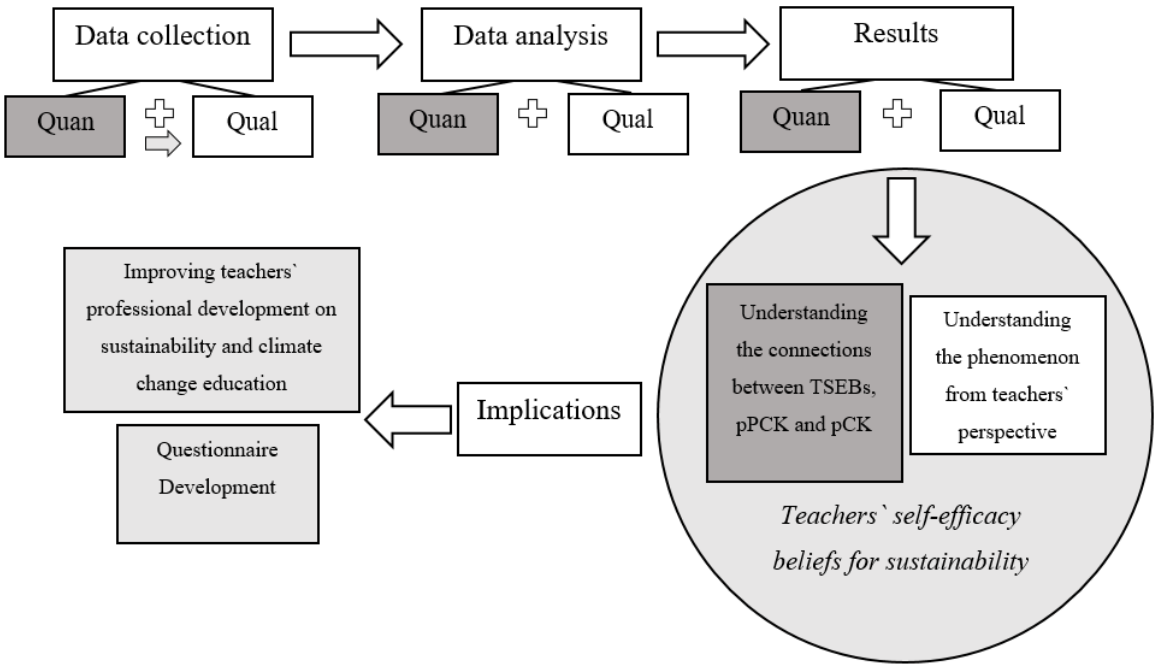

Figure 1. Research design. "Phenomenon" refers to teachers` self-efficacy for sustainability education. "Quan" and "qual" stand for quantitative phase (questionnaire) and qualitative phase (interview), respectively.

Grounded theory (Glaser & Strauss, 1967) was used to analyse data gathered using semi-structured interviews. In the interviews, the teachers were asked about their views about sustainability education and self-efficacy, more precisely i) their experiences in teaching sustainability, ii) their views about themes/areas/concepts that are easy and difficult to teach, and iii) their views about themselves as teachers and learners.

Interviews were transcribed verbatim and coded using ATLAS.ti. Text segments, which were coded included statements or speculation on how the teachers viewed sustainability education; their actions and efforts, as well as conditions for those actions and efforts, such as their reflections on their own teaching profile and knowledge. Open coding phase included coding of the data, grouping of codes into concepts, and categorizing those concepts (see Figure 2).

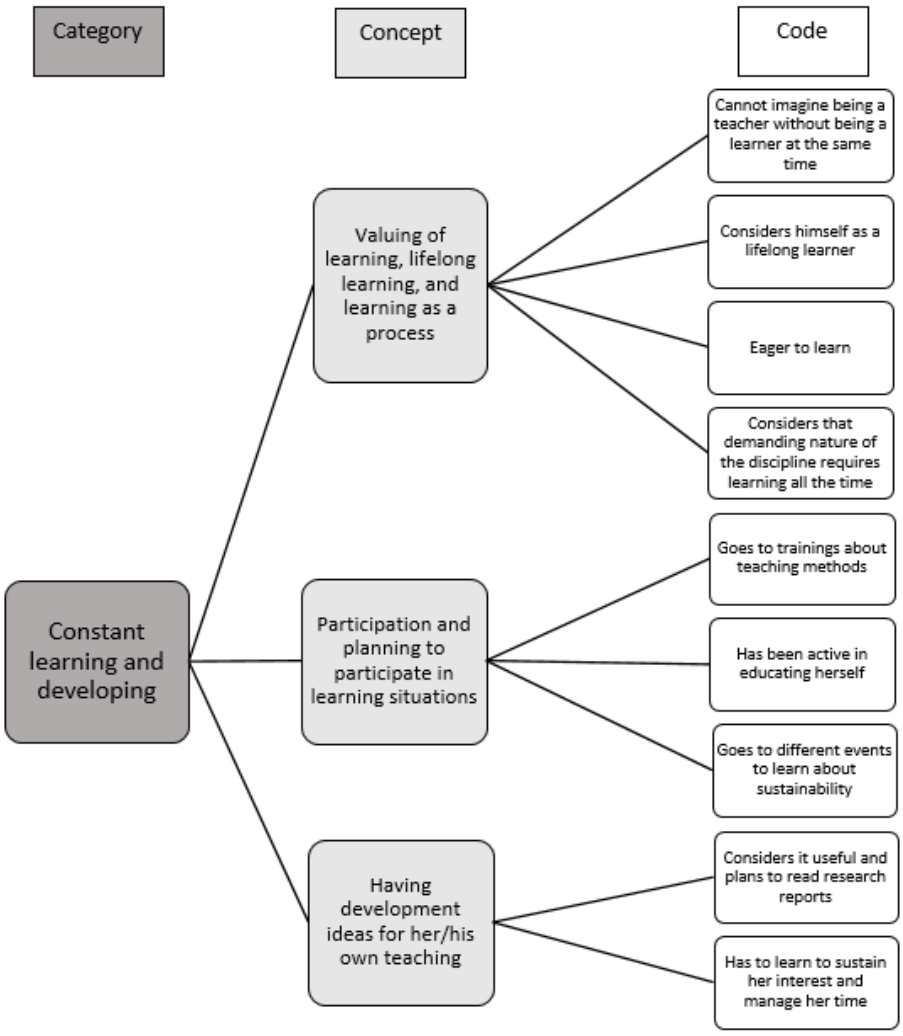

Figure 2. The connection between category, concept, and code (only some of the codes are included in this example).

During axial coding, categories were specified and connected with each other, and core category found. In selective coding, other categories were organized around the core category. In this study, data was coded in two phases, so the analysis was an iterative process. First, ten interviews were coded and categorized through open, axial, and selective coding. Then, another nine interviews were coded, and those codes emerged to existing concepts and categories. As a result, small modifications were made to the initial concepts and categories. Using two rounds of coding helped us to draft a theory and then test it with supplement data. The coding was carried out by the first author.

Credibility was assessed through quality criteria as suggested by Corbin and Strauss (2008). Methodological consistency was aimed at by systematically gathering the data and comparing codes, concepts, and categories. Moreover, codes, concepts,

and categories were anchored to the data as well as possible. In addition, memos were written during the analysis to ensure self-awareness of the process. In this study, two rounds of coding were carried out, making it possible to test the theory. The researcher-related criteria include engaging to the laborious and precise coding and analysis typical to grounded theory.

4 Results

4.1 Quantitative phase: The questionnaire

4.1.1 (RQ1a) TSEBs, pPCK and pCK

As a result to the first research question, we found that teachers felt most confident with content related to sustainable development, and the natural and anthropogenic greenhouse effect, the mean values of which were also close to many of the other topics in the questionnaire (pCK). Precautionary principle and integrational solidarity were estimated to be something that the teachers have less knowledge about. pCK over concepts related to education for sustainable development was on average somewhere just below the “in adequate extent” level (5). Most of the items were just above (4). Statistics of the scale have been gathered in Table 1.

Table 1. The questionnaire scale statistics

	Items	Mean	SD*	Cronbach α
Self-efficacy				
Values and ethics	6	4,98	1,1267	0,863
Systems thinking	5	4,69	1,4633	0,961
Emotions, feelings, and empathy	3	4,85	1,1819	0,915
Actions	10	4,40	1,2490	0,943
Total	24	4,67	1,2587	0,965
Perceived content knowledge	14	4,43	1,7251	0,954
Perceived pedagogical content knowledge	17	4,12	1,4882	0,960
Total	31	4,26	1,6826	0,957

* Average of items` SD-values

Teachers` pPCK was a little bit lower than their pCK. Most of the items were just above (4). (Appendix 1). On average, the TSEBs were somewhere just below “adequately confident (5)”. Highest scores could be found amongst items related to values and ethics, and the lowest related to action, except for the confidence to develop students` local actions, their ability to reflect upon their actions and evaluate them”.

Particularly low was the confidence to develop students' ability to take part in global actions.

4.1.2 (RQ1b) The connection between TSEBs, pCK and pPCK?

The connection between the knowledge items (pCK and pPCK) and TSEBs was estimated using spearman`s correlation (Table 2). For this purpose, pCK items (items 1–14), pPCK items (items 15–31), self-efficacy items (items 32–55), and its components `values and ethics` (items 32–37), `systems thinking` (items 38–42), `emotions, feelings and empathy` (items 43–45) and `action` (items 46–55) were computed as sum of variables. The validity of the sum of variables were evaluated using Cronbach`s alpha (see Table 1).

Table 2. Correlations between knowledge items and TSEBs

Item		pCK	pPCK	TSEBs	TSEBs: Values	TSEBs: Systems	TSEBs: Emotions	TSEBs: Action
pCK	CC N	-	0,553* 18	0,696** 17	0,289 19	0,571* 19	0,452 19	0,635** 17
pPCK	CC N	0,553* 18	-	0,588** 20	0,622** 21	0,568** 21	0,509* 21	0,649** 20
TSEBs	CC N	0,696** 17	0,588** 20	-	0,708** 20	0,948** 20	0,896** 20	0,895** 20
TSEBs: Values	CC N	0,289 19	0,622** 21	0,708** 20	-	0,641** 22	0,556** 22	0,504* 20
TSEBs: Systems	CC N	0,571* 19	0,568** 21	0,948** 20	0,641** 22	-	0,874** 22	0,793** 20
TSEBs: Emotions	CC N	0,452 19	0,509* 21	0,896** 20	0,556** 22	0,874** 22	-	0,760** 20
TSEBs: Action	CC N	0,635** 17	0,649** 20	0,895** 20	0,504* 20	0,793** 20	0,760** 20	-

* Correlation significant at the 0,05 level (2-tailed)
** Correlation significant at the 0,01 level (2-tailed)

As shown in Table 2, almost all sum of variables were correlated. Firstly, knowledge items, pCK and pPCK, correlated at the 0,05 level. They also correlated with TSEBs at the 0,01 level. When we look at the components of TSEBs, systems thinking and action correlate with all of the variables (at 0,01 or 0,05 level). However, pCK does not correlate with values or emotions, but pPCK does.

4.2 Qualitative phase: Grounded theory and teacher interviews

To understand TSEBs for sustainability education in more detail (RQ 2), teachers were interviewed, and interview data analysed using grounded theory.

4.2.1 Continuous learning and developing

According to grounded theory methodology, axial coding resulted in core category, in this case *continuous learning and developing*. It was linked to all other twelve categories, and summarized teachers` views about their actions for sustainability education (see all categories in Table 3). This category includes three concepts, i) valuing learning and life-long learning, ii) participation and planning to participate in learning situations, and iii) having development ideas for her/his own teaching (see Figure 2). For example, one interviewee said that: *"I still think there is room for learning more. Learning more always. Yeah, but I feel quite confident"*. The core category was connected to other categories as those categories more specifically described the consequences of drive of learning and developing.

Table 3. TSEBs categories

Category/ N	Σ
Teachers` beliefs about learning and developing sustainability education	
Continuous learning and developing	43
Acting beyond the curriculum	11
Having ideas on how to develop teaching	18
Open yet critical attitude over teaching methods	17
Preparation for teaching	9
Valuing teacher collaboration	14
Teachers` beliefs of themselves as sustainability educators	
Clear perception of own knowledge on sustainability	16
Clear perception of own teacher identity	22
Understanding of own role	15
Valuing of teacher profession	5
Viewing learners as active inquirers	21
Teachers` beliefs of external factors affecting to their teaching	
Reflection and coping with challenges	27
Sustainability as a target	17
	235

4.2.2 Teachers` beliefs about learning and developing sustainability education

Besides the core category, also five other categories were connected to teachers` beliefs about learning and developing sustainability education (see Table 3). In the `acting beyond the curriculum` category, enthusiasm towards developing teaching is evident as the teachers reported having transferred their expertise also to other teachers and people in general. They did activities beyond what is expected of them as teachers. They for example said having carried out "*workshops during different festivals*" (Teacher 2).

The reasons behind this were clearly expressed by teacher no. 18 who said that: "*I really am ready for much more work*" and in a challenging situation in which the science teacher would not include more sustainability education," he/she would want to do it him/herself. Some of the teachers also considered that the curriculum is not enough. Instead, the teachers have to teach beyond the curriculum, for life.

The teachers seemed to be `having ideas on how to develop teaching`, which was recognized as one condition for teachers` actions because to be able to carry out actions, there needs to be some kind of idea behind it. Frequently they talked about their ideas and then how they themselves put some of those ideas into action. They had ideas on how to carry out sustainability education in practice, such as using practical examples to visualize data or improving the students` critical thinking. They also had ideas on how to improve the curriculum to take sustainability more into account, such as expressed by Teacher 14 who thought that *"it would be much easier if it were just like everything would be immersed in it [to the curriculum]"*.

Teachers seemed to have an `open yet critical attitude over teaching methods`. They were interested in new and different methods of teaching and learning:

> "I am somehow going against the flood, and bringing in creative things, music, videos, rap songs that might affect them better than just the course book". (Teacher 1)

> "Nevertheless, they also had a critical attitude over teaching methods or thought that the teaching methods are something that can be developed, and especially important is to "make links." (Teacher 7)

Teachers reported that they prepare well for their teaching. They said that they study a lot before teaching, and they connected it to their confidence; studying about a topic affects how confident they feel about teaching the topic. They also said that they prepare material for their students:

> "I do a lot of background work to prepare the material to make it easier for them and to make it accessible, not easier in but to make it fun." (Teacher 18)

Teachers were also `valuing teacher collaboration`. They both viewed teacher collaboration important and also actually collaborated with other teachers. In addition to be able to carry out multidisciplinary teacher, they mentioned also learning from others, rather than books etc.

4.2.3 Teachers` beliefs of themselves as sustainability educators

Besides talking about things related to learning and developing, teachers talked about how they viewed themselves as teachers, in particular how they viewed themselves as sustainability educators in the context of climate change.

Teachers had a `clear perception of own knowledge on sustainability` and connected that knowledge to their self-efficacy. They were aware of own knowledge and

compared their own knowledge to knowledge of others. They were also critical about their own knowledge:

> "If it's about science such as the particles today we talked about or some chemical reactions that it will be hard for me. I have limited confidence." (Teacher 6)

Besides knowledge, teachers had a `clear perception of own teacher identity`. They were capable of reflecting on her/himself as a teacher, considered that teaching experiences effect on confidence, and sometimes also considered themselves as being demanding as a teacher, "*expecting more of them than what they can do*" (Teacher 1).

It was interesting how the teachers seemed to be `understanding of own role` as teachers of sustainability. Not all teachers were science teachers for example. They seemed to understand their own place and role in sustainability education in terms of own subject. A language teacher talked about teaching sustainability "*as a cross-curricular topic*", appearing very often as a global issue (Teacher 3).

They understood how they could use their own teacher identity or their own subject in sustainability education. One of the teachers gave examples of how they integrate sustainability topics into their own subject:

> "Many cases we discuss thermoelectric stations, compared to hydroelectric stations, solar, solar farms, wind farms. So, all of this come across the scope of my work, one of the courses that we teach actually now is renewable energy sources, so I never had formal education, but I am very much involved in the sustainability and renewable energy." (Teacher 18)

Teachers also thought that students influence how teachers teach about sustainability, such as the students` level of skills and knowledge or their motivation.

Teachers valued themselves as teachers; they were `valuing of teacher profession` and liked to be a teacher. One of the teachers explained that they value being a teacher more than a researcher considering teachers making an actual influence.

Teachers also described how they were `viewing learners as active inquirers`. They use questions in teaching; ask students questions and ask the students to find answers to their questions. Teachers let the students to do inquiries and projects. Teacher 3 also explained that they "*encourage the students to go farther to make research...to read from books, from newspapers, from the internet*".

In general, teachers viewed the students being in center of teaching. Teacher 18 described teaching to be "*more like a student-centered rather than material-centred*".

4.2.4 Teachers` beliefs of external factors affecting to their teaching

Interviewed teachers also talked about external factors affecting to their teaching, how they reflected and coped with challenges and about the goal in teaching, which they considered to be sustainability.

They talked about `reflection and coping with challenges`. The challenges which they talked about were related to their own teaching, the students` learning, and those linked to collaboration with the other teachers or parents. However, teachers were also ready to cope with the challenges.

These challenges and means to cope with them were expressed in the following way:

> "For me it is difficult to teach this kind of climate change, to explain them, I always do a lot of research before teaching it, and I never use the same material for the other generation because they are always different. Of course, it is always easier when you have taught already, and now I feel that I am getting better but with climate change, explaining those terms from geography, from physics and being a person who is a linguist, it is not an easy one. Sometimes I ask colleagues, but you have to also go with the situation by yourself." (Teacher 1)

During the interview, teachers used a lot of time to describe their thoughts about sustainability and its education. These descriptions were categorized as `sustainability as a target` because teachers expressed their views and worries about sustainability and its education, such as not "*putting for real issues, problems* (Teacher 13)" and reported that they had made choices with sustainability as a target, such as participated in courses.

5 Conclusions

This study aimed at understanding TSEBs in relation to pPCK and pCK in sustainability education in the context of climate change professional development camp. TSEBs for sustainability education in the context of climate change education was described by continuous learning and developing of their own teaching. This description was clear despite of the fact that they did not evaluate their knowledge or self-efficacy high in the questionnaire they answered.

Figure 3 specifies how this study and our understanding of previous research on TSEBs contributes to consensus model of PCK (Kind, 2015) in relation to teacher beliefs as amplifiers and filters. Teachers` beliefs, such as their TSEBs, act as filters through which their knowledge is translated into classroom practices. Based on previous research (Zee & Koomen, 2016) we have illustrated the two components of TSEBs: global self-efficacy and domain/context-specific self-efficacy. As domain specific self-efficacy we mean sustainability and climate change education. Based on our empirical study, we suggest that domain specific TSEBs should not only take into consideration TSEBs about sustainability education learning and teaching as in the questionnaire used in this study (Malandrakis et al., 2019) but also TSEBs about themselves as sustainability and climate change educators. More specifically, in the core of teachers` beliefs, was the teachers` eagerness for constant learning and development, which means that the possible lack of teacher knowledge was not seen as an obstacle for sustainability education, because knowledge and skills can be developed.

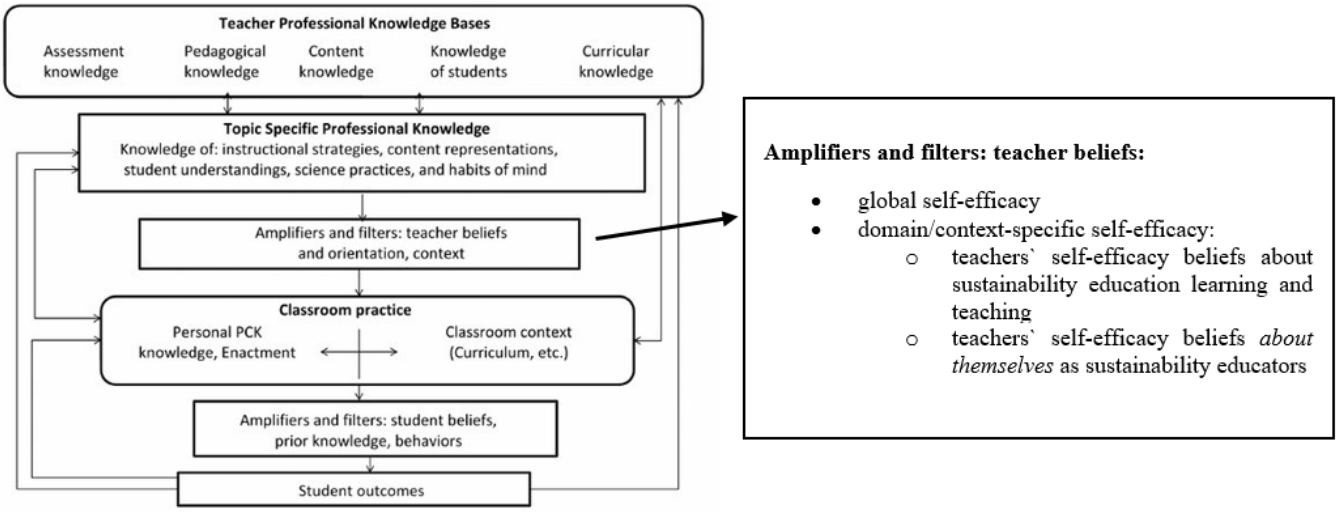

Figure 3. TSEBs about sustainability education and PCK.

6 Discussion

6.1 The role of pPCK and pCK in TSEBs about sustainability and climate change education

To be able to cope with today`s and tomorrow`s challenges related to sustainability and climate change, understanding, and supporting teachers' self-efficacy is in key role. This case study showed that teachers who participated in this study evaluated their content and pedagogical content knowledge to be a bit below adequate level as were their self-efficacy beliefs. The results are inline what has been found before on TSEBs using the same instrument (Malandrakis et al., 2019), suggesting that the studied teachers were not any special group of teachers who would know much more than the teachers in Malandrakis` study.

This study found interesting pieces of information what comes to supporting students` action competence. This study implies that it is not easy for teachers to support students to carry out climate action. Namely, TSEBs related to support students` action, was lower than the other components (values and ethics, systems thinking, emotions, feelings, and empathy). More specifically, they estimated their confidence to develop students' ability to take part in local actions quite high, but their confidence in developing students` global actions the lowest in comparison to the other items. The reason why we point this out, is that over the recent years, sustainability and climate change educators and researchers have emphasized the importance of student action (Mogensen & Schnack, 2010). However, this study does not explain how much this difficulty of teachers to support student action can be caused by teachers own sense of difficulty in carrying out global actions themselves. It would be an interesting follow up study to study the connection between teachers` and students` action competence.

Besides TSEBs, this study was interested in the role of pedagogical and content knowledge in TSEBs. The results showed that teachers` content and pedagogical content knowledge and TSEBs all correlated. The components of TSEBs, systems thinking, and action correlated with all the variables. However, content knowledge did not correlate with values or emotions, but pedagogical content knowledge does. It seems that knowledge alone does not influence on affectional or value-related TSEBs.

6.2 TSEBs about sustainability and climate change education

Despite the fact, that results of the questionnaire showed only adequate values of TSEBs, teachers expressed confidence in many areas of education and sustainability education when they were interviewed. They gave examples of their actions and efforts, and conditions for those actions and efforts, such as their reflections on their own teaching and knowledge. It seems that teachers possible lack of knowledge is not necessarily a barrier for sustainability education. It is of course possible that this holds true in this specific case. In this case teachers were eager to develop their teaching.

In fact, teachers in this study describe themselves as teachers who are continuously willing to learn and have ideas to develop their teaching further. They have clear perception of the contents they know and what they don`t yet know. This view is well in line with the idea of a resilient learner, a learner who especially values the process of learning (Sterling, 2010). Sterling (2010) suggests that the resilient learner should also be able to develop resilient social-ecological systems to achieve the different goals set for sustainability education. We suggest that in joint discussions on views and practices, teachers become more aware of not only their content and pedagogical content knowledge and TSEBs but also how to implement it in teaching and to which goal of sustainability education it aims at.

Teachers also expressed views of external factors affecting to their teaching. This is connected to external and internal control of efficacy (Brouwers & Tomic, 2003). In the studied case, teachers brought up the external factors, but they did not report that the challenges they faced would stop their sustainability teaching efforts. Thus, they seemed to have more internal than external control.

In addition, they viewed themselves as sustainability and climate change educators. We suggest therefore, that TSEBs instruments for sustainability education could include teachers` beliefs of themselves as sustainability educators as part of their domain-specific self-efficacy. Including those aspects requires, however, further validation of the original instrument. Although instruments, such as Sinakou et al. (2021) have been developed aiming to measure sustainability education in a more holistic way, they do not include the aspect of teachers` self-efficacy beliefs.

Besides global, self-efficacy can also be domain-specific (Zee & Koomen, 2016). According to this study, it is still unclear, how much of the TSEBs in this study were global and how much of it was about sustainability education. It could probably be useful for the teachers to develop their general self-efficacy, for example improve their motivation towards learning and developing teaching. Nonetheless, this unclarity is a

limitation of this study. Other limitations include the sample size for the quantitative part, and that we did not plan to connect each of the teachers` responses to the questionnaire to their interviews. This would have probably deepened the analysis. In addition, we measured teachers` perceived content knowledge and pedagogical content knowledge which might differ from their actual knowledge and pedagogical content knowledge.

We suggest that future studies could concentrate on improving TSEBs instruments for sustainability and climate change education to concentrate more on teachers` domain-specific self-efficacy and especially teachers` beliefs about themselves as sustainability and climate change educators.

Beyond instrument development, we suggest that the results of this study would be included in further discussions on how to improve teachers` sustainability and climate change education. We need more research on how to support teachers` efficacy to support students` actions, local and global, because that would make a difference. In addition, this study implied that motivated teachers could cope with challenges in their teaching. How to educate such teachers in the future, is the question that remains unanswered.

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Appendix 1

Table 4. Teachers` self-efficacy beliefs scale

Perceived content knowledge
To what extent do you think that you have the scientific knowledge related to the following concepts?
1. The natural greenhouse effect
2. The man-made (anthropogenic) greenhouse effect
3. Climate change
4. Ozone layer depletion
5. Acid rain
6. Energy footprint
7. Ecological footprint
8. Sustainable development
9. Education for sustainability / education for sustainable development
10. Biodiversity and species extinction
11. Recycling and waste management issues
12. Water pollution
13. Precautionary principle
14. Intergenerational solidarity (in solidarity with the future generations)
Scale: 1-7, in which 1 = not at all, 3 = to some extent, 5 = in adequate extent, and 7 = in a great extent

Perceived pedagogical content knowledge
As of today, how confident are you that you can?
15. evaluate an environmental education / education for sustainability (EE / ES) project that you have implemented
16. use multiple evaluation methods in EE/ES
17. teach environmental education / education for sustainability (EE / ES)
18. use appropriate teaching methods for EE/ES (e.g., field trips, problem solving, etc.)
19. implement an EE/ES project in your school
20. set educational goals about sustainability considering the characteristics of your students (e.g., conceptual development, prior knowledge, individual differences, etc.)
21. develop dynamic learning environments for the teaching of sustainability issues
22. achieve goals ABOUT the environment
23. achieve goals IN the environment
24. achieve goals FOR the environment
25. reveal the ENVIRONMENTAL aspects of the issue under study
26. reveal the SOCIAL aspects of the issue under study
27. reveal the ECONOMIC aspects of the issue under study
28. reveal the POLITICAL aspects of the issue under study
29. reveal the INTERNATIONAL aspects of the issue under study
30. implement the environmental education / education for sustainability (EE/ES) CURRICULUM (program of studies)
31. make explicit the INTERDISCIPLINARY nature of EE/ES (e.g., interrelations among sciences and social sciences, ICTs, arts, etc.)
Scale: 1-7, in which 1 = not at all confident, 3 = a little confident, 5 = adequately confident, and 7 = absolutely confident

Appendix 1 continues
Self-efficacy

Values and ethics
As of today, how confident are you that you can?
32. develop students' VALUES related to sustainable development (e.g., equity, justice, democracy, solidarity, respect to difference)
33. develop students' ETHICS related to sustainable development
34. develop students' ability to DISTINGUISH the right from the wrong behavior
35. develop students' ability to express their OWN OPINION about sustainable development
36. develop students' positive ATTITUDES towards sustainable development
37. develop students' ability to make HYPOTHESIS about problems and possible solutions related to sustainable development

Systems thinking
As of today, how confident are you that you can?
38. develop students' SYSTEMS THINKING
39. develop students' ability to consider an issue through MULTIPLE PERSPECTIVES
40. develop students' ability to realize the INTERRELATIONS among different factors or issues
41. develop students' ability to think using MODELS (e.g., ecosystems model, water cycle, etc.)
42. develop students' ability to act in a SYSTEMATIC WAY in order to achieve the goals they have set (e.g., the implementation of an action, etc.)

Emotions, feelings & Empathy
As of today, how confident are you that you can?
43. develop students' ability to understand their OWN feelings about the various problems in school and the community they live in
44. develop students' ability to understand the feelings of OTHERS about the various problems in school and the community they live in
45. develop students' ability to use their feelings in a creative way, by helping in the improvement of the school and the community they live in

Actions
46. make your students realize that the path to sustainable development includes CONTRADICTORY INTERESTS
47. make your students realize that the path to sustainable development includes a high degree of UNCERTAINTY
48. develop students' ability to examine alternatives and PROPOSE ACTIONS about sustainable development
49. develop students' ability to take part in ACTIONS about sustainable development as INDIVIDUALS
50. develop students' ability to take part in actions about sustainable development as a MEMBER OF A GROUP
51. develop students' ability to take part in LOCAL ACTIONS for sustainable development (e.g., for their school, neighborhood, community, etc.)
52. develop students' ability to take part in GLOBAL ACTIONS for sustainable development (e.g., participation in international environmental organizations, boycott of products, etc.)
53. develop students' ability to discuss possible CHANGES in their suggested actions
54. develop students' ability to REFLECT upon their actions
55. develop students' ability to EVALUATE their actions

Scale: 1-7, in which 1 = not at all confident, 3 = a little confident, 5 = adequately confident, and 7 = absolutely confident