What and why in teaching about sustainability – Swedish science teachers’ emphasis on content choice when teaching Sustainable Development

Abstract
Education has responded to global Sustainable Development (SD) goals by drawing on a range of issue-related, context-based, and cross-curricular approaches to teaching SD. This paper aims to examine how teachers describe the content in SD and how they justify this content concerning their teaching practice. The Pedagogical Content Knowledge (PCK) framework, with its reflective tool Content Representation (CoRe), was used in combination with semi-structured interviews to capture 18 Swedish upper-secondary science teachers’ reflections. The results indicate four themes of content that the teachers emphasise: energy and global warming, ecosystem services and biodiversity, presence of harmful substances and materials in nature, and imbalance of natural substances in nature. The teachers justified these content themes in terms of the importance of students’ gaining different perspectives (local, global, ecological, social, and economic), belief in the future, action competence, and general scientific education. The paper contributes to sustainability education research, as it focuses on teaching sustainability in the light of the PCK framework. Also, it can support and inspire teachers when they decide what content to include when teaching SD.
INTRODUCTION

The globe suffers from ongoing environmental problems that require serious attention. Therefore, during the last decades, questions around sustainability have been strongly emphasised in society and education. Sustainable development (SD) is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). SD expresses a direction, a possible and desirable future, for which school and education become crucial factors. However, research into teachers’ professional knowledge and the need for such SD teaching is an emergent field. Certain key aspects need a deeper understanding to support teacher development and the teaching of sustainability in upper secondary schools. The curriculum in Sweden expresses, on an overall level, that teachers are supposed to consider the environmental perspective and promote students’ willingness and ability to act and adapt their life to create SD (Swedish National Agency for Education, 2023a). The science curriculum briefly expresses that the SD content shall include energy, climate, and ecosystem (Swedish National Agency for Education, 2023b). As SD is not typically delivered in a particular curriculum area but is dealt with through a set of cross-curricular goals to which many curriculum areas contribute, teachers’ perceptions of specific content areas in teaching SD become of interest. Further, the actual content for teaching SD is not clearly described in the curricula, which might confuse or even cause uncertainty among teachers. This study focuses on teaching SD in upper secondary school science in Sweden. The study aims to examine how teachers describe what kind of content they include when teaching SD and how they justify that content concerning their teaching practice.

The SD focus in the study relates to several adjacent research fields, such as Scientific Literacy, Socio-scientific Issues (SSI), Environmental Education (EE), and Education for Sustainable Development (ESD). Research in these fields is extensive, and several studies indicate the importance of teaching for a sustainable future (e.g. Sund, 2015; Öhman & Östman, 2019). However, as argued earlier, more research is needed to problematise the teaching content in SD, why teachers choose this content, and how teachers unpack that content into teaching to promote students’ learning. Therefore, this research uses the framework of Pedagogical Content Knowledge (PCK) with a particular focus on what content teachers choose and how they justify that content when planning to teach SD in upper secondary school.

PCK is unique knowledge that teachers develop through experience over time (Gess-Newsome, 2015), and PCK has become a cornerstone of a teacher’s professional knowledge and expertise (Loughran, Berry & Mulhall, 2012). However, as PCK is often described as tacit and inaccessible (Bertram & Loughran, 2011), the way it is captured, interpreted, and used by teachers is not always easy to describe. To capture and describe teachers’ PCK, Loughran, Mulhall and Berry (2004) introduced a reflective tool, Content Representation (CoRe). This tool is valuable for capturing, formulating, and developing teachers’ PCK in different contexts (Bertram & Loughran, 2011; Hume & Berry, 2013; Kind, 2009; Nilsson & Loughran, 2012; Van Driel & Berry, 2017). In this study, CoRe was used to capture teachers’ reflections. The following two questions guided the study:

1) What content do teachers emphasise when teaching SD in upper secondary school science education?
2) In what ways do teachers justify this content?

As such, with the focus on teachers’ PCK of SD, with a particular emphasis on how teachers choose and justify the content for teaching SD (e.g. in relation to the curricula), this study has the potential to inform both the teaching of SD and curriculum development.
LITERATURE REVIEW

Sustainability education research

The focus on the sustainability content in this study relates to the adjacent research fields of Scientific Literacy, SSI, EE, and ESD. Below they are described briefly.

The characteristics of a scientifically literate person were unpacked by Rennie (2005), who emphasised that scientifically literate people are: interested in and understand the world around them; engaged in the discourses of and about science; able to identify questions, collect data, and draw evidence-based conclusions; sceptical and question claims made by others about scientific matters; and, able to make informed decisions about the environment and their health and wellbeing.

To promote the research field of scientific literacy, SSI emphasises the ability to apply scientific and moral reasoning in real situations. Research has shown that SSI can be effective in increasing students’ understanding of science in different contexts; reasoning ability, decision-making, argumentation, critical thinking, ethical and moral reasoning (Christenson & Walan, 2022; Sadler, 2004; Zeidler & Keefer, 2003; Zeidler & Sadler, 2008).

Another broad worldwide field of research is EE. For example, Finn (2017) claims that EE is essential for raising students’ awareness of many environmental issues and can bring about a shift in attitude and encourage human lifestyles that support ecological wholeness. In the Swedish historical context, three selective traditions have been identified (Sund, 2015), and research in other countries has demonstrated similar traditions (Sauvé, 1999; Stables, 2006; Vare & Scott, 2007). The three Swedish selective traditions are the fact-based tradition, the normative tradition, and the pluralistic tradition (Sandell, Öhman & Östman, 2005; Sund, 2015; Öhman & Östman, 2019). The fact-based tradition views environmental issues as scientific, mainly ecological issues that can be processed by more people gaining more scientific knowledge. The focus of the teaching is on scientific facts and concepts. In the normative tradition, environmental problems are mainly value issues, which are regarded as a conflict between man and nature due to humans’ lifestyle. Teaching has an expected causal connection between knowledge, values, and behaviour. The pluralistic tradition of ESD was developed in the 1990s. Within this tradition, environmental issues are about conflicts between different human interests (Sandell et al., 2005; Sund, 2015; Öhman & Östman, 2019). The three pillars of SD give shape and content to sustainable learning and are key SD areas in international discourse (UNESCO, 2005).

There has been a transition from EE toward ESD (Sund, 2015). The purpose of ESD is to provide the students with knowledge about SD from a deep, broad, school-wide perspective and the competence to act in favour of SD (Jensen & Schnack, 1997). Further, Mogensen and Schnack (2010) argue that it is of the utmost importance to reflect on the democratic values that teaching for ESD strives to promote. Lundegård and Caiman (2019) present five forms of democratic participation that they have systematised and reviewed from previous research. The five forms are important for teaching sustainability issues and include (1) student participation in deliberation, (2) agency, (3) creativity, (4) criticism, and (5) authenticity. In ESD, the teachers, in their teaching practices, include matters such as interdisciplinary teaching and participation in real-life issues as well as the concept of action competence. Action competence indicates that teachers create opportunities for students to identify and take an active position on issues within the environmental area (Lundegård & Wickman, 2007, 2012; Olsson, Gericke & Boeve-de Pauw, 2022). Sass, De Maeyer, Boeve-de Pauw and Van Petegem (2023) examined the learning outcome of an action-oriented educational approach. They concluded that an action-oriented educational approach is effective as students’ self-reported action competencies became higher if they received action-oriented ESD education.
Researchers recognise that education about global issues and sustainability also includes emotional aspects due to the seriousness and complexity of these problems (e.g. Eilam & Trop, 2011; Ojala, 2023). Hope is an emotional and cognitive concept, where students’ feeling of constructive hope for the future is associated with teachers who possess a future-oriented, positive, and solution-oriented communication style (Ojala, 2015).

SSI, as well as ESD, implicate the complexity of teaching sustainability. The question of what kind of content to teach arises. In this paper, we investigate the type of content teachers choose when teaching SD and why they think this content is important for students to know. As such, by researching the content in SD teaching, this study will make an important contribution to the research fields described above.

**SD in the Swedish curriculum**
The Swedish curriculum for upper-secondary schools highlights SD in the following way:

‘The environmental perspective in teaching should give the students insights so they can contribute to preventing harmful environmental impacts and acquire a personal approach to overall and global environmental issues. The teaching should highlight how society functions and how our way of life and work can be adapted to create sustainable development’. (Swedish National Agency for Education, 2023a).

As such, SD must permeate the entire education. However, the science curriculum stipulates, among other things, that teaching should allow students to develop their knowledge and skills with the following core content (Table 1) (Swedish National Agency for Education, 2023b).

![](index.png)

**Table. 1 The table presents the knowledge and skills, and core content in the science curriculum related to SD (Swedish National Agency for Education, 2023b).**

<table>
<thead>
<tr>
<th>Knowledge and skills</th>
<th>The ability to use scientific knowledge to discuss, form views, and formulate different courses of action.</th>
<th>Knowledge of the role of science in current social issues in relation to sustainable development.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core content</td>
<td>Issues concerning sustainable development: energy, climate, and impact on the ecosystem. Ecosystem services, utilisation of resources, and the viability of ecosystems.</td>
<td>Different aspects of sustainable development, such as consumption, allocation of resources, human rights, and gender equality.</td>
</tr>
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**Pedagogical Content Knowledge**
Almost 40 years ago, Shulman introduced the concept of PCK. He claimed that content knowledge and pedagogical knowledge are inseparable from each other in promoting student learning (Shulman, 1986, 1987). Shulman pointed out the importance of teachers’ understanding of how content knowledge applies in the teaching situation and how this relates to the student’s learning processes (Shulman, 1986).

After Shulman’s introduction of PCK, the idea of a specialised form of professional knowledge that sets teachers aside from other professionals has been adopted and adapted in different research con-
texts internationally. Many researchers (e.g. Gess-Newsome, 2015; Magnusson, Krajcik & Borko, 1999; Park & Chen, 2012; Park & Oliver, 2008) have explored how such knowledge develops and how this development might be successfully supported.

In 2019, Chan and Hume presented a systematic review of the science education literature to identify how researchers investigate science teachers’ PCK. They identified different knowledge categories and PCK components in conceptualising PCK (Table 2). This study explores how teachers’ content knowledge (CK), knowledge of curriculum (KC), and orientations to teaching science (OTS) form the basis for their choice of content in teaching about SD. CK implies the part of teachers’ subject matter knowledge that is pertinent to the teaching task. KC refers to teachers’ knowledge of the subject’s goals in the syllabus. KC also includes the teachers’ knowledge of the importance of content in relation to the whole curriculum, enabling them to identify core concepts and main ideas and eliminate trivial facts. OTS refers to a set of beliefs that includes teachers’ goals and objectives of science teaching, teachers’ views of science, and teachers’ perceptions of science teaching and learning (Chan & Hume, 2019).

Table. 2 The table presents definitions of the different knowledge categories and PCK components (Chan & Hume, 2019, pp. 15-17). Those that are the focus of this study are marked in bold.

<table>
<thead>
<tr>
<th>Knowledge category</th>
<th>Assessment knowledge (AK)</th>
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<tbody>
<tr>
<td>Content knowledge (CK)</td>
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<tr>
<td>Contextual knowledge (CxK)</td>
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<td>Curricular knowledge (CuK)</td>
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<td>Knowledge of students (KS)</td>
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<td>Pedagogical knowledge (PK)</td>
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<td>PCK components</td>
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<tr>
<td>Knowledge of assessment (KA)</td>
<td></td>
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<td>Knowledge of curriculum (KC)</td>
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<tr>
<td>Knowledge of instructional strategies and representations (KISR)</td>
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<tr>
<td>Knowledge of students’ understanding (KSU)</td>
<td></td>
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<tr>
<td>Orientations to teaching science (OTS)</td>
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</table>

The reflective tool CoRe

The CoRe tool is a systematic reflection and planning tool designed by a group of Australian researchers in 2004 (Loughran et al., 2004) to support teachers in reflecting on the didactic questions of why, how, what, when, and for whom in relation to teaching. The tool was developed based on the nature of PCK and how PCK can be captured, interpreted, and used by teachers concretely. By having teachers reflect on the positions they are expected to take in the classroom, the CoRe tool contributes to increasing the teacher’s awareness of teaching around a certain content (Loughran et al., 2004). Research in the field describes the CoRe design as successful since it clarifies and makes visible different dimensions of and connections between knowledge of content, teaching, and learning about a specific subject area in science (Bertram & Loughran, 2011; Hume & Berry, 2013; Kind, 2009; Nilsson & Karlsson, 2019; Nilsson & Loughran, 2012).

A CoRe encourages science teachers to articulate ‘Big Ideas’ in a content area and respond to questions about what students should learn about each Big Idea, why this is essential for students to learn and what teaching procedures should be used to teach these ideas. The Big Ideas represent the central
idea and concepts within a particular science content area. Thus, Big Ideas are not just pure facts; instead, a Big Idea constitutes general knowledge, an important phenomena or concepts that are worth knowing within a specific content area (Nilsson & Loughran, 2012a). Approaching the topic by identifying Big Ideas allows teachers to focus on known causes of student concerns and build pedagogically powerful episodes for students (Mitchell, Keast, Panizzon & Mitchell, 2017). The numbers of Big Ideas are optional, and every Big Idea is reflected through eight questions/prompts (Bertram & Loughran, 2011; Hume & Berry, 2011; Loughran et al., 2004; Nilsson & Loughran, 2012).

As this study focuses on the content of SD and how teachers justify that content, the focus is on the identified Big Ideas and the two first questions in the CoRe:

1) What do you intend the students to learn about this idea?
2) Why is it important for students to know this?

The purpose of the first question is for teachers to consider *what* learning they expect their students to achieve. With the Big Idea at the forefront, the second question intends to help the teachers reflect and articulate *why* this learning is essential for students (Nilsson & Loughran, 2012). By using these questions in the CoRe tool, we intend to capture and articulate teachers’ CK, KC, and OTS in SD.

**METHOD**

In the study, two complementary methods have been used to collect data. First, the teachers completed a CoRe with SD as a given subject matter, and second, semi-structured interviews with the teachers were performed. The data was analysed through thematic analysis (Braun & Clarke, 2006, 2019).

**The empirical context**

The context of the study is general science education in upper secondary schools in Sweden. In Sweden, students between 16 and 19 years old attend upper secondary school in different fields of study. The compulsory general science education programme is organised into two science courses: Science 1a1 and Science 1b. The students who have chosen a vocational preparation study path attend Science 1a1, and those who have chosen humanities, economics, and social science study paths attend Science 1b. Both courses have the same curriculum concerning SD (see Table 1).

**Research design and data collection**

Eighteen in-service teachers (seven men and eleven women) teaching Science 1a1 and 1b participated in the study. The teachers worked in seven upper secondary schools in different parts of Sweden. The schools offered vocational and academic study paths. The only selection criterion used was that teachers were science teachers. The schools contacted were selected randomly, and participation was voluntary. The first author personally contacted the principals of various schools and thereafter contacted the science teachers. Some teachers had seen an invitation to the research project via social media and got in touch. The first author met and introduced the participants to the CoRe tool and the theoretical framework of PCK. This introduction included a presentation, a book chapter about PCK and CoRe (Nilsson, 2012), and an empty template of the CoRe (Loughran et al., 2004; Nilsson, 2012). Some teachers asked for clarification, mostly about how to express a Big Idea. The answers were strictly general and only repeated what was included in the introduction session.

The teachers were given the task of filling in the template independently and formulating Big Ideas for teaching SD, as well as responding to the prompts for each Big Idea in the CoRe template. There was no time limit for this task. A semi-structured individual interview followed, where the teachers could narrate and reflect on their teaching in SD concerning their CoRe. Each interview lasted for approximately 60 minutes. During the interview, the teachers were asked to explain how they concluded the Big Ideas. They reflected on their Big Ideas in response to the CoRe questions and the researchers’ in-depth questions. The interviews were audio-recorded and transcribed. All data was collected in...
the teachers’ mother tongue (Swedish), and the transcripts were translated into English. The teachers will be referred to as teacher 1-18 (T1-18). When the quote comes from the teachers’ CoRe, it is marked with a ‘c’ at the end, and when the quote comes from the transcribed interview, it is marked with an ‘i’.

**Data analysis**

The empirical data for this paper consists of the transcribed interviews and the teacher’s written CoRes, focusing on the Big Ideas and the first two prompts in the CoRe.

Braun and Clarke’s reflexive thematic analysis (TA) was used to analyse the data. Reflexive TA is a further development and clarification of TA and is a thematic analysis in which the researchers’ subjectivity and reflexivity are central (Braun & Clarke, 2006, 2019). Within qualitative research, reflexive TA is about meaning-making, which is always context-bound. Braun and Clarke (2019) conceptualise themes in TA as patterns of a shared meaning that is underpinned or united by a core concept.

Based on the description of the different steps in TA (Braun & Clarke, 2006), the following steps were taken for the data analysis:

- In the first step, the transcribed interviews and the CoRes (with a particular focus on the identified Big Ideas and the first two prompts) from the 18 teachers were carefully read.
- In the second step, the headings of the teacher’s Big Ideas were clustered regarding content.
- In the third step, the initial codes were generated regarding the first research question. Essential excerpts were marked.
- In the fourth step, the coded extracts generated subthemes and themes regarding the first research question.
- In the fifth step, the second research question was processed. The themes identified for the first research question constituted the base for identifying codes to create themes in the data that answered the second research question. Codes and essential excerpts were marked. The codes were collated and generated four themes that answered the second research question.
- In the sixth step, the final analysis was performed. The researchers reflected together in a recursive process until a consensus was reached. The analysis was refined and deepened over time.

The 18 teachers each wrote between three to eight Big Ideas. In total, they generated 79 Big Ideas that they emphasised as crucial for teaching SD. Of these Big Ideas, 56 were specifically related to a particular science content area, whereas the other 23 focused on more general aspects of SD and arguments for why this content is important. The first 56 Big Ideas formed the basis for the first research question. All 79 Big Ideas were in focus for the second research question.

The findings presented below are supported by data showing evidence of the participant’s contribution in the form of quotations. In this study, we refer to validity as measuring what is relevant in the context and reliability as measuring in a reliable way. Concerning validity, the implementation of the method, analysis of data, and documentation of results have been discussed and reflected on by all three researchers, which, according to Newton and Burgess (2008), ensures process and outcome validity. Concerning reliability, the CoRe was used to capture the teachers’ PCK in a reliable way. As mentioned, the CoRe has been designed from research and used in several studies to capture teachers’ PCK. As such, research has indicated that it is a reliable tool in this sense. Cohen, Manion and Morrison (2011) indicate that the use of different methods might strengthen the validity and reliability of the data collection and analysis. Therefore, combining different methods or types of data to study a phenomenon likely leads to a more accurate description than if only one method was used. In this study, both written CoRes and oral interviews were used.
FINDINGS
The findings are structured in two parts. First, the results of the question ‘what content do teachers emphasise when teaching SD in upper secondary school science education?’ are presented. The second part presents results from the question, ‘in what ways do teachers justify this content?’.

This study presents data from 18 teachers. As such, the study can only draw results from those particular teachers and does not provide any basis for generalising the results to all science teachers as a professional group.

Teachers’ choice of content when teaching SD
The 56 Big Ideas that focused on content were clustered into four main themes and eight subthemes (Figure 1). Of the teachers’ 56 Big Ideas, 20 were clustered into the first theme, 16 into the second theme, 12 into the third theme, and 8 into the fourth theme. The first theme is thus the one the teachers think is most important, where its two subthemes have 10 Big Ideas each. The four main themes include:

1. Energy and global warming
2. Ecosystem services and biodiversity
3. The presence of harmful substances and materials in nature
4. The imbalance of natural substances in nature

![Figure 1 Science teachers’ content in the teaching of SD expressed in four main themes with two subthemes each.](image-url)
Energy and global warming

Most of the teachers emphasised that energy and global warming are solid and essential content when teaching about SD. The two subthemes precede the theme of energy and global warming:

• Energy conversion, energy sources and energy production
• Causes, mechanisms, and consequences of global warming

To be able to understand energy issues in SD, teachers claimed that it is necessary for students to have basic knowledge about energy, such as energy conversion and forms of energy. One of the teachers expressed it like this:

‘Considering how energy-dependent we are in society; it is a good start to have a basic idea of what energy is and what the basic forms are for energy.’ (T1i)

‘Basic understanding of energy and that energy cannot be destroyed.’ (T1c)

With this knowledge, students can understand the primary mechanism of energy production for human needs. The teachers highlighted the need for students to know about the different forms of power plants.

‘We have talked about how a coal power plant works, and a hydropower plant and a wind power plant, and someone might then see that they are quite similar.’ (T3i)

Another main content item that the teachers emphasised was the possibilities and challenges associated with different energy sources. The division between energy sources into renewable and non-renewable was highlighted, and teachers argued for the need for students to frame energy sources in a real societal context.

‘To look at the question of renewable and non-renewable energy. We want the students to be oriented about what it is and what we use in Sweden.’ (T2i)

Hence, the teachers expressed that knowledge about renewable and non-renewable energy sources is essential.

Several teachers emphasised that global warming is a central issue in teaching SD. They linked the non-renewable energy sources to the causes of global warming and described the mechanism of the greenhouse effect and the consequences. One of the teachers described the content knowledge as a chain:

‘It will be a kind of chain where you look at the reason why we have global warming, what is the greenhouse effect and what are the mechanisms, i.e. how it really works with the greenhouse effect, and finally, we look at possible consequences of this.’ (T3i)

Another teacher wanted the students to realise the actual situation of the globe and how the greenhouse effect may affect the future.

Ecosystem services and biodiversity

Many of the teachers highlighted the importance of teaching about the ecosystem with content related to cycles in nature and biodiversity. The main theme was sorted and coded into these two subthemes:

• Cycles and ecosystem services
• Biodiversity

The teachers stated that a fundamental aspect regarding the content in teaching SD is cycles in nature for various substances and materials (e.g. the carbon cycle, the nitrogen cycle, and the water cycle). They also emphasised human impact on the cycles and that humans’ use of food and gadgets needs a functioning cycle. Below are some examples from the teachers’ reflections:

‘I think they need to understand that... I usually divide it into water, air, food, nitrogen, carbon, metals, and waste, how they can be included in a cycle, and how they can reuse them.’ (T5i)
The teachers also highlighted the need for an understanding of ecosystem services. In other words, all the products and services that ecosystems provide to humans and that contribute to our wellbeing and quality of life.

‘I do not think they [the students] understand that everything we have comes from nature. That we use it in different ways, and we cannot run out of it. We must protect it. We are not outside nature; we are part of it. The students need a holistic approach; I think this is important.’ (T5i)

In addition, biodiversity was part of the teachers’ teaching in SD and was often connected to teaching about ecosystems. The teachers wanted the students to understand the complexity and importance of biodiversity for SD. The excerpts below illustrate some examples of comments:

‘We are bad at knowing how balance is achieved in an ecosystem, but diversity contributes to stability.’ (T1c)

‘And so it is with biodiversity; it is not about us having a certain number of flowers in a meadow, but it is so much, much more.’ (T7i)

**Presence of harmful substances and materials in nature**

The main theme ‘presence of harmful substances and materials in nature’ was coded into two subthemes:

- Environmental toxins
- Plastics in the ocean

The teachers expressed that, when teaching SD, environmental toxins in different forms are an actual and insidious environmental problem. Common to all the teachers was a desire for the students to understand why environmental toxins are dangerous for all life and humans because of accumulation. An example of a comment:

‘The concentration of environmental toxins upwards in the food chain. Cause and effects.’ (T8c)

The teachers also wanted the students to understand the complexity of environmental toxins.

‘All environmental toxins are used for something, and every property will also be a disadvantage, so to speak. If we kill a type of life, it will, of course, affect another form of life.’ (T8i)

One of the harmful materials in nature that some of the teachers highlighted is plastics in the ocean, both the harm that plastics might do to the animals in the oceans and the problem with microplastics and what effects they may have. The students need to understand that ‘plastics in the sea increase and form microplastics.’ (T9c)

**Imbalance of natural substances in nature**

The main theme ‘imbalance of natural substances in nature’ was coded into two subthemes:

- Eutrophication
- Acidification

Several teachers emphasised that eutrophication is an environmental problem that is crucial to address when teaching SD. The Baltic Sea was used as an example to show the complexity of solving the problem. One example was the focus on the ecological perspective and the consequences of eutrophication with algal blooms and bottom death.

The teachers also highlighted the reasons for eutrophication:

‘Students need to know that nutrients that end up in the wrong place in excessive quantities can negatively affect the environment and impact our lives. It is important to know where the nutrients come from.’ (T11c)
Another content item mentioned in teaching SD was acidification, what it is and how it affects nature. The students need to know about sulphuric acid, what it is, where it comes from, and how it is formed in the air and the atmosphere. ‘This is an environmental problem that is very local to us with our acidified lakes and acidified forests.’ (T10i). As sulphuric acid affects nature and forestry financially, this is a critical concept to raise in teaching SD.

**Summary of the content when teaching SD**

Four main themes and eight subthemes were identified that covered teachers’ choice of content when teaching SD. Aspects that the teachers emphasised were energy conversion, renewable and non-renewable energy sources, and energy production. The teachers also highlighted that teaching about energy serves as a foundation for teaching about the causes, mechanisms, and consequences of global warming. The teachers also expressed humans’ impact on ecosystem cycles and the lack of biodiversity as important content related to SD. Furthermore, environmental toxins, their ability to accumulate, and problems with plastics and microplastics were highlighted as important content. The issue with eutrophication, especially in the context of the Baltic Sea, was also highlighted as important content. Finally, acidification was a selected content item.

The content that the teachers emphasised as necessary concerning SD provides a theoretical knowledge foundation for the students, so that they can understand the complex issues in SD where multiple aspects integrate. In the next section, we present the findings regarding how teachers justified the chosen content when teaching SD.

**Justifications for choosing content**

The 18 CoRes with the follow-up interviews were used to answer the second research question: “in what way do teachers justify this content?”. After analysis, four themes were identified:

1. **Local-global perspective and ecological, social and economic perspective**
2. **Belief in the future**
3. **Action at an individual level and in global cooperation**
4. **To be able to participate in society – scientific general education**

Figure 2 below indicates the complex relationship between the content chosen and the arguments supporting this content. The thicker lines indicate that the relationship between ‘Energy and global warming’ is more frequently emphasised in the teachers’ reflections for themes 2 and 3 than for the others.
What and why in teaching about sustainability

Figure 2 The figure presents the four main themes of the content in SD and how the teachers justify these themes within their teaching for SD. A thicker line indicates a stronger relationship.

The figure above shows how each of the four main themes connects to all four themes of justification. As such, one justification is relevant for more than one main theme. This demonstrates the complexity of teaching SD and how teachers emphasise and further justify different content to engage the students to act towards a possible and desirable future.

Local-global perspective and ecological, social and economic perspective
One characteristic of the teachers' reflections was an effort to make the students understand all three dimensions of sustainability (ecological, social, and economic) to gain insight into its complexity. For example, one teacher mentioned all the dimensions when teaching about floods as a consequence of global warming:

'Socially, ecologically, and economically, yes, what are called the three pillars of sustainable development. When you talk about consequences, the students can connect to it, or I connect to it. So that you see that here we have all three parts. For example, if we have floods, it can be linked to economic, ecological, and social aspects.' (T3i)

Many teachers highlighted the complexity of the different levels in SD from a local and a global perspective. Concerning the local perspective, one teacher emphasised that acidified lakes and forests affect wildlife from a local perspective. Concerning the global perspective, one teacher commented on the challenge of water sharing between different countries and how emissions from one country might affect another country's ecosystem.

These examples show that the teachers emphasised both the local and the global perspectives.

Belief in the future
The second theme was the importance of developing students' beliefs in the future when teaching SD. The theme relates to all the main themes of content, though the most frequent connection was to the main theme of energy and global warming. The teachers' argument was focused on not worrying the students too much.
‘To give some hope that there is an opportunity to turn this around and impede natural disasters and deserts everywhere and so on, I’m thinking so. Yes, because it is probably the case that they do not look very positively at their future, and then you should not weigh them down even more, I think.’ (T12i)

Teachers also reasoned about the concept of climate anxiety and the teachers’ responsibility to protect the students from that and to avoid resignation by giving hope. For example, one teacher expressed that the teaching in SD also influenced her own feelings. This showed that teaching SD is complex, with an affective dimension that teachers need to deal with.

‘Yes, I think it is important for all students that if you have climate anxiety, there is no actionable feeling in it in any way. I think our task as adults, or as teachers, is somewhere to instil some hope. Even though you do not feel that hope yourself, you must pretend, I think. I feel a little sad myself when I think about this and am a little hesitant. But I try to give them a little better feeling; I feel that is my responsibility.’ (T13i)

By aligning teaching with the G20 countries’ goal, that global warming should not exceed 1.5°C, several teachers emphasised the seriousness of global warming. At the same time, they wanted to instil hope by presenting different strategies and demonstrating that it is still possible to bring about change. One teacher stressed the need to instil hope and suggest different solutions among students, stating:

‘Students must understand with both the brain and the heart the importance of the global warming goal and that it is possible to achieve.’ (T14c)

The teachers wanted the students to gain confidence in the future – that sustainability is possible to achieve. They also wanted students to have that confidence on several levels, both intellectually and emotionally.

**Action at an individual level and in global cooperation**

As already mentioned, the teachers argued for the importance of giving a feeling of hope for the future. They even wanted to take it a step further and stimulate students to take action at an individual level and in global cooperation.

Teachers exemplified recycling connected to ecosystem services and personal choice of food connected to global warming and eutrophication:

‘Yes, but if we take recycling, they are part of the solution when they take responsibility for what they themselves buy and what they do when they have to throw this away. They are responsible for their own consumption. And if they make sure they have responsible consumption, they also make sure that they are part of the solution.’ (T5i)

‘If we have that perspective, we could eat crops instead and fill up on those instead of pork. So, to be a little aware of what it is you put on the plate, it can also affect the environment from different perspectives, not only for carbon dioxide but also for nutrient emissions.’ (T11i)

Some teachers mentioned the necessity of global cooperation. The teachers tried to make the concept of global cooperation understandable for the students and possible to implement by demonstrating the possibility of organising together with others to make a tremendous difference: ‘Individuals can do a little bit, but for it to really make a difference and give effect, then many must do it, and then it will be required that you group yourselves or something.’ (T10i)

One teacher emphasised climate conferences in teaching and that global cooperation gives hope for the future: ‘I refer back to the COP26 climate conference in Glasgow and that we will get through this.’ (T14i).

The theme related to all the main themes of content, though the most frequent connection was to the main theme of energy and global warming.
To be able to participate in society – scientific general education

The last theme that became clear as justification for the teachers’ choice of content was the overall goal that students should receive a general science education. The teachers highlighted that this is important to be able to participate in society.

One teacher argued that students need the knowledge to make conscious choices by obtaining a general scientific education to be a part of society. The teacher gave nuclear power as an example:

‘This is a critical discussion that has been going on for a very long time. What energy sources do we want, and do we not want? We in Sweden chose to invest in nuclear power in the 70s; now, we do not. In some countries, it is still done, and in other countries, this has never been done. They must understand the discussions that are going on. They must be generally educated. They must be conscious citizens who can make conscious choices.’ (T2i)

The teachers used current media, such as film and newspaper articles, to strengthen the students’ general scientific knowledge. One example was:

‘Dagens Nyheter [name of the newspaper] had exciting articles where they linked biological diversity to the coronavirus outbreak, how we sort of remove habitats that make things move, and then it has serious consequences.’ (T7i)

The teachers also used the importance of scientific general education to motivate students to study. One teacher recounted the argumentation with the students about the importance of understanding and being involved in everyday science conversations during the coffee break at their internship and in future professional life. Another teacher talked about the importance of having scientific knowledge within SD on the day you move away from home, when you must choose an electricity agreement, among other things.

Finally, several teachers expressed how teaching SD provides general knowledge that is highly topical and that the students benefit from – for life.

Summary of justification for choosing the content

The teachers’ justification for the chosen content within SD was identified into four themes. Firstly, the students need the selected basic content knowledge to be able to reflect on and discuss SD issues from an ecological, social, and economic perspective. Content knowledge is also a precondition for understanding that issues in SD are present at different levels simultaneously: from the local-global perspective. Secondly, the teachers claimed that it is important to have knowledge about the reasons, mechanisms, and consequences of, for example, global warming since knowledge may counteract climate anxiety and create a strong belief in the future. Thirdly, the teachers justified their overall content as potentially leading to action competence, both at an individual level and in cooperation. Finally, the teachers argued that the chosen content was something the students needed to know to be able to participate in a democratic society.

DISCUSSION

As expressed in the introduction, the ambition of this study was to problematise the content in teaching SD and how teachers justify what content is of importance for students to have within this field. The theoretical framework PCK, with its developed and well-researched tool CoRe, has supported us in this ambition. When the teachers used the CoRe tool, it supported and facilitated their reflections on their PCK, focusing on SD. The CoRe encouraged the teachers to articulate Big Ideas – their central ideas and concepts within SD (e.g. making explicit their CK and KC). As noted by Mitchell et al. (2017), big ideas help teachers think about and better understand the ‘essence’ of what they are teaching, and constructing big ideas is helpful for teachers in explicating their purposes.
The findings showed that the content chosen for SD in the science education courses is connected to current environmental problems such as energy issues and global warming, reduced biodiversity, eutrophication, and environmental toxins. If we relate this content to the core content expressed in the Swedish curriculum (Table 1), we can see that it corresponds to a great extent. However, the description of the content of the syllabus is neither detailed nor comprehensively described. Therefore, we suppose a teacher’s choice of teaching content will likely be influenced by the teacher’s CK and KC in an interwoven combination. Further, as Chan and Hume (2019) indicated, the teachers’ orientations to teaching science (OTS) influence the way they choose and justify the particular content of SD. The teachers’ beliefs and views of what content is important for students’ learning and engagement influenced their goals and objectives as well as their perceptions of teaching SD.

The findings in this study present four significant themes for the teachers’ justification for their content, justifications shaped through the teachers’ CK, KC, and OTS. The theme of local-global perspective and ecological, social, and economic perspective shows that the teachers are part of the prevailing pluralistic tradition of ESD (Sandell et al., 2005; Sund, 2015; Öhman & Östman, 2019). The teachers’ ambition was to problematise the environmental problems in a societal context and for students to obtain knowledge of that complexity. The theme belief in the future was an essential and fundamental idea in the teachers’ justification for the content. Teachers claimed that creating a feeling of belief in the future is a necessary basis for teaching SD. Ojala (2015, 2023) argues that it is vital for teachers to have a communication style that promotes a feeling of constructive hope in students. We derive this finding from the teachers’ OTS, suggesting that the teachers’ purpose and goals for teaching SD have a profound and far-reaching dimension. The findings on the theme of action at individual level and in global cooperation indicate that many teachers want the students to gain environmentally-friendly values on an individual level. These findings relate to EE’s normative tradition, where teaching has an expected causal connection between knowledge, values, and behaviour (Sandell et al., 2005; Sund, 2015). The findings also state that many teachers argue that humans must take an active position on issues within SD and work together towards a future sustainable society. This result aligns with the research of Sass et al. (2023), which concludes that students’ self-reported action competencies become higher if they gain action-oriented ESD education. As Lundegård and Wickman (2012) suggest, action competence is vital for our shared future. The theme is also connected to SSI, as it emphasises the ability to apply scientific and moral reasoning in real situations (Sadler, 2004; Zeidler & Keefer, 2003; Zeidler & Sadler, 2008). The Swedish curriculum also expresses the importance of action competence (Swedish National Agency for Education, 2023a, 2023b). Therefore, it is likely that teachers’ justification for why this is important is a combination of influencing factors from CK, OTS, and KC. The theme to be able to participate in society – scientific general education also relates to ESD focusing on democracy issues in teaching (Lundegård & Caiman, 2019; Mogensen & Schnack, 2010; Sandell et al., 2005). The teachers argued that their chosen content was important, since the knowledge might help students to make informed choices in life and take part in a society based on democracy. The theme also relates to Scientific Literacy; Rennie (2005) identifies a scientifically literate person as interested in and understand the surrounding world, and able to identify scientific questions and make informed decisions about the environment.

This study has supplemented earlier research in Scientific Literacy, SSI, EE, and ESD. We believe that more research on teaching SD linked to teachers’ PCK could add valuable knowledge to those research fields.

Finally, this study can serve as support and inspiration for teachers when they decide what content to include when teaching SD. Preparing Big Ideas about SD and making explicit what students should learn about these Big Ideas, as well as why this content is important for students to learn, can be a valuable contribution for teachers from this paper.
REFERENCES


Chan, K. K. H., & Hume, A. (2019). Towards a consensus model: Literature review of how science teachers’ pedagogical content knowledge is investigated in empirical studies. In A. Hume, R. Cooper, & A. Borowski (Eds.), Repositioning Pedagogical Content Knowledge in Teachers’ Knowledge for Teaching Science (pp. 3-76). Springer. https://doi.org/10.1007/978-981-13-5898-2_1


Gess-Newsome, J. (2015). A model of teacher professional knowledge and skill including PCK: Results of the thinking from the PCK summit. In A. Berry, P. J. Friedrichsen, & J. Loughran (Eds.), Re-examining pedagogical content knowledge in science education (pp. 28-42). Routledge.


