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5th–10th-grade in-service teachers' pedagogical content knowledge (PCK) for sustainable development in outdoor environment

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ABSTRACT

Teachers' experiences and attitudes play a critical role in outdoor education. In this study, we aim to explore how 5th–10th-grade (10–15 years-old students) teachers use the natural environment in their teaching practices, with special attention to the link to sustainable development (SD). In total, 42 in-service teachers were invited to participate in the study. The data collection was based on the participating teachers' individual written texts concerning their previous outdoor teaching practices, the link to SD and the related assessments. Based on content analysis, three main themes emerged from the data, including (1) teaching biology/ecology concepts, (2) exploring visible pollution and (3) applying a context- and inquiry-based approach. However, we found that outdoor teaching was scarcely linked to SD. The research results' implications for outdoor education and teachers' professional development are discussed in this paper.

KEYWORDS

In-service; 5th- to 10th-grade teachers; sustainable development; pedagogical content knowledge (PCK); outdoor teaching; outdoor environment

Introduction

Today, when people use digital equipment and spend more time indoors than they did in the past, it is important to promote outdoor learning (Marcum-Dietrich, Marquez, Gill, & Medved, 2011; Skår, Wold, Gundersen, & O'Brien, 2016). Outdoor learning has been defined in different ways and can be seen as all curriculum-based activities that are happening outside the classroom (Education Review Office, 2011; Remmen & Frøyland, 2017). However, Priest (1986) emphasise the importance of relationships involving both people and natural resources in the outdoor learning, which is the interpretation of outdoor learning we base upon in this article. In this study, we regard it as school-based learning in out-of-school settings with a natural or a cultural landscape or on school grounds with natural surroundings, following the Scandinavian context (Bentsen, Jensen, Mygind, & Randrup, 2010).

Time spent outdoors has been found to be positively correlated to children's cognitive and behavioural development (Ulset, Vitaro, Brendgen, Bekkhus, & Borge, 2017), as well as engagement in learning (Fägerstam, 2014; Nadelson & Jordan, 2012; Remmen & Frøyland, 2014). Additionally, it has already been revealed that fieldwork offers substantial evidence for learners to develop their knowledge and skills in ways that add value to their everyday experiences and learning in the classroom (Dillon et al., 2006; Lock, 2010). Besides, outdoor education has been recognised for its contribution to sustainable development (SD) (Ampuero, Miranda, Delgado, Goyen, & Weaver, 2015; Jegstad, Gjøtterud, & Sinnes, 2018; Paulus, 2016; Prince, 2017).

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Internationally, SD is perceived as an increasingly important goal for global well-being. However, what is SD? In this article we are in line with the report from The Brundtland Commission, Our Common Future (UN World Commission on Environment and Development, 1987) which states that 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (p. 41). Based on target 4.7 'By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development' in the United Nations' (2015, p. 21) 2030 Agenda for Sustainable Development, UNESCO's (UNESCO, 2015, p. 50) Incheon Declaration for Action lines up indicative strategies including strategies to acquire the skills and knowledge along with values the learners will need throughout life to reach this target.

SD is not new in Norwegian context. According to the present Natural Science subject curriculum knowledge, understanding and experiences in nature should enhance the students' willingness to protect natural resources, preserve biodiversity and contribute to sustainable development (Norwegian Directorate for Education and Training, 2013). To date, SD is also especially emphasised in the new curriculum in Norway (to be released in the autumn of 2019) as one of the three interdisciplinary cornerstones (together with public health and life management, and democracy and citizenship) (Ministry of Education and Research, 2017). Meanwhile, the draft of the new curriculum concerning the subject of natural science in Norway includes competence objectives in primary and secondary education to be able to both engage in inquiry-based learning and work in the natural environment (Norwegian Directorate for Education and Training, 2019). Inquiry-based teaching and learning is not a new approach to developing students' learning and thinking skills (e.g. critical thinking and problem solving) and has been addressed in and beyond Europe (Abd-El-Khalick et al., 2004; European Commission, 2007). Connected to inquiry, context-based teaching and learning has also proven powerful in enhancing students' learning interest and awareness of the relevance of science (Gilbert, 2006; Pilot & Bulte, 2006; Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013). In the combination of inquiry- and context-based teaching, socioscientific issues (SSIs) are recognised internationally as providing a good context for SD, which needs to be embraced in teachers' professional development (Rundgren & Rundgren, 2018).

In the Scandinavian context, with its location, rich natural environment and culture of enjoying the woods and nature, outdoor education has been applied at different school levels, from preschool to secondary school, in varying degrees (Fägerstam, 2014). However, in addition to the impact of teachers' epistemological beliefs on their teaching (Hashweh, 1996), research has shown that teachers' experiences and attitudes (Burmeister, Rauch, & Eilks, 2012; Fägerstam, 2014) play a critical role in their engagement in the outdoor environment in their teaching practice. Studies show that pre-service teachers' positive experiences of the outdoors relate to their engagement in outdoor teaching in their future teaching practice (Blatt & Patrick, 2014; Vadala, Bixler, & James, 2007), which brings to the fore the urgent need to embed outdoor education in teacher education today (Jegstad et al., 2018). Based on the importance of the teachers' role, outdoor education for children's development and the goal of SD, our aim in this study is to explore whether 5th–10th-grade in-service teachers are able to link their outdoor teaching in the natural environment to sustainability. In particular, we argue that outdoor teaching for SD ought to be developed as part of teachers' professional knowledge, called pedagogical content knowledge (PCK) (Shulman, 1986, 1987).

Promoting SD through outdoor education

Several researchers have discussed the benefits of outdoor learning for students' learning from the perspectives of Dewey's experiential learning and transformative experiences (Jegstad et al., 2018; Wong & Pugh, 2001). Promoting SD through outdoor education can also be linked to inquiry-based learning (Burmeister et al., 2012; Dillon, 2012; Norwegian Directorate for Education and Training, 2019). Pluralistic epistemology for sustainability is discussed as well and can be embraced in outdoor education by sharing and recognising different perspectives and values in outdoor settings (Paulus,

2016; Sandell & Öhman, 2010), which is highly related to the contexts that teachers provide or to students finding themselves spending time outdoors (Fägerstam, 2014).

The natural environment can be beneficial for learning due to its richness, which naturally offers multiple types of stimulation for learning and in line with Gardner's idea of entry points (Gardner, 1991). According to Goswami and Bryant's (2007, p. 20) view concerning 'the development of multi-sensory networks of neurons across the entire brain' (2007, p. 20), learning a concept may rely on simultaneous stimulation in several parts of the brain.

Studies has also disclosed that providing students with opportunities to work with hands-on activities in a contextualised education like an outdoor setting can make learning more relevant to them (Fägerstam & Blom, 2013; Lugg, 2007). Besides, Lugg (2007) mentions that outdoor curriculum and pedagogical development may make a positive contribution to sustainable-literate citizens.

Importance of developing teachers' pedagogical content knowledge (PCK) for SD linked to outdoor education

Based on the above-mentioned importance of outdoor education for SD and teachers' critical role in it, we argue that SD and outdoor education need to be developed as part of teachers' professional knowledge in the teacher education programme. This is also pointed out by international colleagues (Lugg, 2007; Lugg & Slattery, 2003). Shulman (1986, 1987) has pointed out the requirements for teachers' professional knowledge, so they could become qualified teachers. The categories of teachers' professional knowledge, at the minimum, include the following:

> **content knowledge; general pedagogical knowledge**, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter; **curriculum knowledge**, with particular grasp of the materials and programs that serve as "tools of the trade" for teachers; **pedagogical content knowledge**, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding; **knowledge of learners and their characteristics; knowledge of educational contexts**, ranging from the workings of the group of classroom, the governance and financing of school districts, to the character of communities and cultures; and **knowledge of educational ends, purposes, and values, and their philosophical and historical grounds** (Shulman, 1987, p. 8).

Shulman's ideas presented more than 30 years ago already indicate the complexity of teachers' professional knowledge and roles.

Today, PCK has been the focus in a number of science education studies as an important aspect for developing professional science teachers (e.g. Nilsson, 2014). The term is well known in relation to didactics, since the idea of PCK 'goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching' (Shulman, 1986, p. 9). 'Research on teaching and learning coincide most closely' with PCK (Shulman, 1986, p. 10). In later years, the categories of teachers' professional knowledge mentioned by Shulman (1987) have been re-discussed by researchers. For example, Magnusson, Krajcik, and Borko (1999) define PCK with the elements of orientation in the field (i.e. inquiry-based learning), teaching strategies, students' preconceptions or alternative concepts, curriculum and assessment. More recently, Fischer, Borowski, and Tepner (2012) have tried to represent teachers' professional knowledge with the consideration of PK (pedagogical knowledge), PCK and CK (content knowledge) and in their definition of PCK, which ought to include similar elements, as addressed by Magnusson et al. (1999). However, Fischer et al. (2012) view PCK as an integrated PK and CK. Regardless of what PCK contains, Van Driel, Beijaard, and Verloop (2001) emphasise that PCK is a way of understanding the interrelationship of PK and CK via an integrated process, which is rooted in teaching practices. In line with the emphasis of teaching practice, according to Van Driel et al. (2001), pre-service teachers usually have very little or even no PCK, which shows the need for conducting more research on PCK. Research has also disclosed that in-service teachers need continuous professional development (CPD) on PCK, and professional reflection is an important aspect to embed in CPD programmes (S.-N. C. Rundgren, 2015). This finding has

shown the importance of developing pre- and in-service teachers' PCK in their professional development. However, our search with the keyword PCK in the ERIC database (retrieved 23 May 2019) generated only 465 hits, including reports. In this study, we perceive that SD is CK, and how teaching SD in the natural environment is recognised as PCK, which should be further investigated in teachers' professional knowledge.

Research purpose and questions

Based on the above-mentioned literature review, the importance of outdoor education and its connection to SD and teachers' professional knowledge and experiences are addressed. The purpose of our study is to explore how 5th–10th-grade in-service teachers engage in the natural environment in their teaching practice, with special attention to SD. The specific research questions focus on some of the PCK categories regarding the learning objectives, strategy and assessment, as follows:

(1) What activities do the teachers design while bringing their students to a natural environment?
(2) What are the teacher-designed activities' learning objectives and/or relation to SD?
(3) How do the teachers design their assessments in relation to the outdoor activities?

Methods

Research design and participants

This small-scale exploratory study was based on 42 in-service teachers' reflections (18 females and 24 males) on their previous teaching practices for SD in outdoor environments. All the teachers were following the curriculum released in 2013 emphasising SD in outdoor settings (Norwegian Directorate for Education and Training, 2013). All the teachers were attending a CPD programme in science education to obtain the formal qualification to teach science to pupils aged 10–15 (5th–10th grades). They represented both rural and urban schools in a wide range of regions across Norway. Most of the teachers (N = 31) had long teaching experience (> 6 years), but only 15 teachers had long experience (> 6 years) in teaching science. This means that some of the teachers had longer teaching experiences in different subjects other than science. The detailed backgrounds of the participating in-service teachers are shown in Tables 1 and 2.

Table 1. The ages of the participants.

Age (years)	Number of teachers
20–29	7
30–39	19
40–49	14
> 49	2

Table 2. The participants' teaching experiences.

	Other subjects	Science subject
Teaching experiences (years)	Number of teachers	
0	0	4
1–5	10	23
6–10	12	8
> 10	19	7

Data collection and analyses

The data were collected from two groups of in-service teachers while they attended a course on campus (located in Oslo centre) dealing with a lesson about education for SD, which was held for one of the groups in March and the other in April 2019. The 42 participating teachers (T01 to T42) were each given a questionnaire to share their previous outdoor teaching activities and the related learning objectives, as well as the link to SD and assessment methods via individual written texts. Then, small group discussions were organised for the participating teachers to share their outdoor teaching practices collectively. The questionnaire was written in Norwegian and translated into English, as shown in Table 3.

After the data collection, the participating teachers' responses to the questionnaire and the groups' summaries were transcribed and saved in NVivo 12 program for further data analysis. The content analysis method was used by reading and re-reading the teachers' texts several times before the themes emerged. A senior researcher (with research experience in science education for 20 years) was involved in ensuring the validity and the reliability of the data analysis. The data were analysed in Norwegian but presented in English under the Results section of this article.

Ethical considerations

The participating teachers filled in the questionnaire anonymously, and no person's identifiable information was collected. Before the data collection period, the study had gone through and passed the ethical check via the Norwegian Centre for Research Data (NSD) (https://nsd.no/). The teachers were also given informed consent forms (see Appendix A) to determine whether or not they wanted to share their responses. The use of the information for research purposes only and all the ethics-related information were addressed in the consent form.

Results

In this section, we present the outdoor activities with their related learning objectives and the link to SD based on the themes obtained from our data. Furthermore, we reveal how the teachers conducted the assessment linked to the outdoor activities.

Outdoor activities, learning objectives and relation to SD

Our study showed that the participating teachers embraced natural environments in their teaching in various ways. The following three main themes emerged from our data:

(1) teaching biology/ecology concepts,
(2) exploring visible pollution and
(3) applying a context- and inquiry-based approach.

Table 3. The questionnaire used for data collection.

PCK categories to reflect on	Your reflection with examples
What activities did you usually do while bringing your students to a natural/outdoor environment?	
Which natural environments (e.g. forest, lake or …) did you bring your students?	
How did you link these activities to any learning objectives?	
How did you link these activities to Eeducation for Sustainable Development	
If you had conducted any assessment related to the outdoor activities, how did you do it? Which learning outcomes did you assess?	

Concerning the activities related to SD, 10 of the 42 teachers did not link their activities to SD, and the most frequent responses regarding the learning objectives were about understanding nature conservation and how humans had affected nature. The three main themes disclosed in the data are delineated as follows.

The first theme was about **teaching biology/ecology concepts** via the use of natural environments. The teachers took nature trips to conduct different forms of fieldwork. In taking their pupils outdoors, their aim was to achieve the competence objectives addressed in the curricula concerning biological diversity and ecology. The teachers commonly made observations on a specific ecosystem, such as a lake or a forest/woodland, systematically examining the area's biological diversity by counting and using other measurements. One of the most experienced teachers (14 years of teaching experiences in other subjects and one year in science) wrote: *'Field analyses, ecosystems —study of biotic and abiotic factors'* (T30). Others were more specific in their descriptions, such as collect and register animal and plant species by biological identification keys or use the pH measurement in exploring water quality.

In relation to SD, many teachers mentioned it in connection with both biological diversity and human interference with the fragile ecological balance. One teacher (T03) wrote about linking the activities to SD: *'Learn about the ecology, how everything is connected and interacts'*. He/she also pointed out the focus on *'how to take care of the environment'*. Another teacher (T02) presented a lot of outdoor activities that he/she linked to SD. In collaboration with a local organisation for nature preservation, he/she let the students *'work to recover a natural habitat for a specific bird species in the school's neighbourhood'*. In this way, the students also found and became acquainted with different kinds of small water animals and creepy crawlies, such as insects or crustaceans, as part of the biological diversity topic.

The second theme emerged in relation to **exploring visible pollution**. The teachers conducted activities in connection with recycling, litter found in the school's locality or plastic waste on beaches. One of the teachers wrote: *'We collect rubbish outside and reuse it to make a piece of art—recycling'* (T17). Another noted: *'We clean up the beach, collect and register the plastic waste'* (T15).

Several teachers mentioned their participation in locally arranged clean-ups, which was found to be mostly linked to SD. One teacher (T06) indicated her pupils' involvement in activities held on a *'coastal clean-up day'* as part of *'a larger theme project about plastic in the ocean'*.

Regarding the third theme, 8 of the 42 participating teachers applied a **context- and inquiry-based approach** in connection to natural environments. One teacher wrote about letting his/her students *'play football on artificial grass for 20 minutes—all [the pupils] shake off the rubber granulate'* (T08). He/she further connected this activity to the students' discussion about the alternative materials to rubber granulate.

Later, in the small group discussions, the participating teachers generated more ideas on activities, such as conducting context- and inquiry-based teaching and learning how the local municipal businesses sort recyclable rubbish according to their source materials. They let their students put up insect hotels and nesting boxes, connect their inquiries to local politics or discuss about how humans affected nature.

Assessments of students' outdoor learning

The participating teachers used different kinds of assessments linked to their outdoor activities but did not necessarily conduct the assessments in any outdoor environment. The assessments found in the study included those conducted in (1) outdoor settings, using oral formative assessment (three teachers) or a questionnaire (four teachers), and (2) indoor settings (16 teachers), using the laboratory report genre (11 teachers), as well as presentations with posters, videos or PowerPoint, which were used together with other oral assessments. Some teachers also mentioned writing subject CK essays and argumentative texts or testing students on their species knowledge.

As described, many of the teachers used assessments via their students' writings, which took place in the classroom after the outdoor activities. The teachers used various written tasks to assess their students' learning. Variations in tasks ranged from the students' logbooks or reflection notes to more academic writing, such as laboratory reports and argumentative texts. On teacher wrote: *'After the fieldtrip, we [they] write a short reflection note. This can make [them more] conscious of the learning objectives'* (T09). One teacher cited an example of academic writing: *'[The students] deliver a [laboratory] report after the activity. [I] have assessed the academic content and form (if they follow the [laboratory] report genre)'* (T31).

Some teachers also mentioned a combination of written and oral assessments after the outdoor activities. The students were asked to write reports, followed by a discussion or an oral presentation. Only a few teachers assessed the students' learning outcomes in outdoor settings with both written and oral tasks. The writing task could be a questionnaire or a quiz, for example, *'answer [written] questions that are handed in after the fieldtrip'* (a teacher from the group discussion summary), or an exercise where the students were supposed to fill in the blanks. One teacher described the way that he/she performed oral assessments outdoors: *'[I] work at the primary level and have just been doing formative assessments outside. I have been conducting oral activities'* (T07).

Discussion and implications

Concerning teachers' PCK for SD in outdoor environments, the three main themes found in our study were (1) teaching biology/ecology concepts, (2) exploring visible pollution and (3) applying a context- and inquiry-based approach. In the first category, it was shown that most of the teachers linked their outdoor education to the curriculum. They conducted various biological fieldworks in line with the requirement addressed in the curriculum. The concept of SD was not recognised in the teachers' reflections on their outdoor teaching. Many teachers did not perceive the link between studying nature and how it could be related to SD. The participating teachers were unaware of how knowledge about nature and the experience of being in the natural environment could contribute to students' care for nature (Sandell & Öhman, 2010). The teachers also did not recognise that closeness to nature could engage students in SD (Jegstad et al., 2018; Lugg, 2007; Paulus, 2016; Prince, 2017) and how useful it would be for deeper learning (Stuckey et al., 2013). Although the participating teachers brought their students outdoors, offering the latter various and practical experiences for learning (Fägerstam & Blom, 2013; Gardner, 1991), the connection of SD to their outdoor teaching was not found to a large degree.

Concerning the use of outdoor environments to explore visible pollution, several teachers brought their students to the coast to join the *'coastal clean-up day'* and one teacher (T06) mentioned these activities as part of *'a larger theme project about plastic in the ocean'*, which was tightly linked to SD. However, some aspects of SD, such as empathy and critical thinking, were not addressed (Ampuero et al., 2015) in the teachers' reflections. The participating teachers were found to be more focused on the discussion about plastic and environmental problems of today. Surprisingly, some teachers mentioned that bringing the students outdoors to pick up waste by the roadside was only intended to make the streets clean in the spring time.

In the example of making the students play football on the artificial grass and collecting and measuring the rubber granulates, the outdoor task was performed using a context- and inquiry-based approach. The teacher (T08) reasoned about his/her own teaching design from this viewpoint: *'The inquiry with the football [students playing on artificial grass] often naturally leads to a discussion [in class] about choices of materials and about alternatives'*. This teacher reflected on how the activity could be linked to SD and engaging the students in SSIs for SD (C.-J. Rundgren & Rundgren, 2018), which is in line with a strategy of making the natural sciences relevant to the students' lives (Gilbert, 2006; Pilot & Bulte, 2006; Stuckey et al., 2013). Another example of putting outdoor activities in the context of SD is the teacher's and his/her students' engagement in the recovery of a natural habitat in the school's neighbourhood. This was also an ideal context to make learning relevant to the students (Gilbert, 2006; Pilot & Bulte, 2006; Stuckey et al., 2013), in line with the importance of

providing students with rich experiences to help them gain an in-depth understanding by using multiple entry points (Gardner, 1991).

Regarding the study's implications, we argue for the need to embrace outdoor education in professional development programmes for both in- and pre-service teachers as part of their professional knowledge development (Lugg, 2007; Lugg & Slattery, 2003). As addressed, outdoor learning is beneficial for children's cognitive and behavioural development (Ulset et al., 2017) and engagement in learning (Fägerstam, 2014; Nadelson & Jordan, 2012; Remmen & Frøyland, 2014), besides adding value to their everyday experiences and learning in the classroom (Dillon et al., 2006; Lock, 2010). However, teachers' epistemological beliefs (Hashweh, 1996), experiences and attitudes (Burmeister et al., 2012; Fägerstam, 2014) play a critical role in their engagement in outdoor environments with their teaching practice. Therefore, if educational policymakers and practitioners do not make the change early, from childhood and/or the teacher training period, outdoor teaching and learning will increasingly dwindle in primary and secondary education.

We also advocate for the strong need for design-based research on SD as part of outdoor education at different school levels. In our study, only a limited number (42) of 5th–10th-grade in-service teachers' teaching practices were disclosed. It is necessary to investigate teachers' practices for SD in outdoor environments with a larger sample size and in different countries, since SD is a global goal.

An outdoor environment provides a natural and rich learning context. Therefore, the need to promote outdoor education for SD in teacher training (as part of teachers' professional knowledge) and school teaching practices should be addressed further, while we also recognise the obligation to protect the environment in this global age. More explorative and design-based research will be able to present pre- and in-service teachers, teacher educators and educational researchers with the evidence of outdoor education for SD.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Charlotte Aksland is an assistant professor of science education in the Department of Primary and Secondary Teacher Education at Oslo Metropolitan University (OsloMet) in Norway. Before starting at OsloMet in 2015, she had been a biology and chemistry teacher in upper secondary school for 20 years. Her research focus has been on the natural environment as a learning arena and on students' understanding of science concepts.

Shu-Nu Chang Rundgren is a professor of didactics and the research leader of the group called Competences for Modern Citizenship (CMC) in the Department of Education at Stockholm University in Sweden. Before joining Stockholm University in 2014, she was a professor of science education for four years at Karlstad University in Sweden. Currently, she is also a guest professor in the Department of Primary and Secondary Teacher Education at OsloMet in Norway. To achieve sustainable development and responsible citizenship, developing teachers' professional knowledge and competencies in teaching and assessing students' key competencies (with a focus on critical thinking and argumentation skills about controversial issues) have been her research focus.

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Appendix A.
Outdoor Education and ESD

Oslo March 2019
To the students in the CDP-program in natural science at OsloMet

Outdoor education and education for sustainable development (ESD) is a project where I want to find out how teaching about sustainable development can be better and more practical. Sustainable development is one of the three interdisciplinary cornerstones on which the new Norwegian curriculum will be based, and I think that teaching out in nature can be a great contribution to this.

In connection with my research, I want to use data, from this lesson, in form of this reflection note and notes from the group discussion.
Personal identification data will not be linked to this research. All data is completely anonymous.

□ The reflection notes and notes from the group discussion can be used in research

I have been a teacher for _____ years
I have taught natural science for about _____ years

Sex:
□ Female
□ Male

Age:
□ 20–29
□ 30–39
□ 40–49
□ ≥ 50