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The perceived effect of environmental and sustainability education on environmental literacy of Czech teenagers

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ABSTRACT

The article presents findings from a Czech environmental literacy survey conducted in 2020 on a sample of 6th ($N=3773$), 8th ($N=21518$), and 9th graders ($N=4368$). Specifically, the effect of environmental and sustainability education (ESE) as well as the effect of gender and age on environmental knowledge, attitudes, beliefs, place attachment, locus of control and behavior were analyzed with regard to teaching strategies. The analyses revealed significant differences between respondents who participate in residential outdoor environmental education programs, those who were involved in a school eco-club or a nature-oriented non-formal-education youth clubs compared to those not involved in these activities. In addition, the perceived holistic, emancipatory, and community-based ESE approaches were among the significant predictors of environmental literacy. The findings support the relevance of the ESE strategies examined in shaping environmental literacy of young students. Older students and boys showed a lower level of pro-environmental values and behavior.

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KEYWORDS
Environmental literacy; survey; emancipatory approach; community-based approach; holistic approach

Introduction

An explicit aim of environmental and sustainability education (ESE) is to develop adolescents' environmental awareness, skills, competence, attitudes, beliefs, and capacity to act (Tbilisi Declaration 1977), i.e. their environmental literacy (Roth 1992; Hollweg et al. 2011; EPA 2021). For example, the mission of the North American Association for Environmental Education (NAAEE, cit. 2022) is to 'use the power of education to advance environmental literacy and civic engagement to create a more equitable and sustainable future.' However, the capacity of ESE to achieve this goal is a matter under consideration – Coyle (2005), for instance, argued that while ESE does work, it has not spread widely enough to have a high impact on public environmental literacy. Similarly, Salmon (2000) pointed out the inadequate quality of environmental education materials. Recently, Edsand and Broich (2020) found only weak evidence in support of environmental education's impact on students' environmental literacy. Therefore, gaining a better understanding of the capacity and limits of ESE regarding the promotion of environmental literacy is clearly a primary challenge of the ESE field.

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This study focuses on the impact ESE has on students' environmental literacy. It is based on a nation-wide environmental literacy project conducted in the Czech Republic in 2019–2021. The study's main aim is to analyze the following areas: (a) what is the level of the participating Czech students' environmental knowledge, attitudes, beliefs, and behavior – that is, their environmental literacy; (b) how is the level of the students' environmental literacy related to the way they experience ESE in their schools; and (c) how is the students' environmental literacy influenced by their gender and age.

The concept of environmental literacy

Students' environmental literacy is a traditional area of ESE research. The concept of environmental literacy usually encapsulates aspects such as: environmental awareness and sensitivity; in-depth understanding of possible solutions to environmental problems; environmentally relevant values, motivation, skills, and competences to protect the environment; and willingness to act (Roth 1992).

According to Hollweg et al. (2011),

> environmental literacy combines knowledge of environmental concepts and issues, the attitudinal dispositions, motivation, cognitive abilities, and skills, and the confidence and appropriate behaviors to apply such knowledge in order to make effective decisions within environmental contexts. Individuals demonstrating degrees of environmental literacy are willing to act on goals that improve the well-being of other individuals, societies, and the global environment, and are able to participate in civic life. (p. 5-15:5-16)

Environmental literacy seems to be influenced by various demographic factors. While most studies have been national, a bi-national study by Kroufek, Çelik, and Can (2015) found only small differences between the groups of Czech and Turkish pre-service primary-school teachers. Svobodova (2021) identified the same level of environmental literacy among students from four Central European countries. Very often, females have been reported as more strongly environmentally oriented in most of the investigated components, including environmental attitudes and behavior (Tuncer Teksoz et al. 2013; Liefländer and Bogner 2016; Nurwaqidah, Suciati, and Ramli 2020; Özer-Keskin and Aksakal 2020; Goodale 2021; Svobodova 2020, 2021; Schneiderhan-Opel and Bogner 2020), with only a limited number of studies not reporting gender differences (Shephard et al. 2013). Age seems to be particularly important, with younger students tending to report a lower level of environmental knowledge and skills but a higher level of pro-environmental attitudes and behavior than older students (McBeth et al. 2008; Negev et al. 2008; Liefländer and Bogner 2014; Svobodova 2020; Baierl, Kaiser, and Bogner 2022). Olsson and Gericke (2015) identified an 'adolescent dip,' referring to the finding that the level of students' 'sustainability consciousness' was significantly lower for 9th graders as compared to 6th graders. In addition, the area of residence (Spinola 2016) and the level of the mother's education seem to influence students' environmental literacy in some countries (Pe'er, Goldman, and Yavetz 2007; Özer-Keskin and Aksakal 2020).

Approaches to measuring environmental literacy

Environmental literacy of diverse target groups has been repeatedly analyzed in many countries, including Taiwan (Hsu and Roth 1998, 1999; Liu et al. 2015), Israel (Negev et al. 2008; Yavetz, Goldman, and Pe'er 2009), China (Cheng and So 2014), South Africa (Swanepoel, Loubser, and Chacko 2002), Turkey (Tuncer et al. 2007; Erdogan and Ok 2011), Macedonia (Srbinovski, Erdogan, and Ismaili 2010), the United States (McBeth et al. 2008, 2011; McBeth and Volk 2009), Indonesia (Nurwaqidah, Suciati, and Ramli 2020), the Philippines (Nunez and Clores 2017), and Portugal (Spinola 2016).

As the concept of environmental literacy requires measuring a wide range of variables, analyzing environmental literacy calls for developing a theoretical model that defines and

operationalizes all of environmental literacy's components. In the United States, the MSELS (Middle School Environmental Literacy Survey) instrument was designed to conduct a national representative survey of environmental literacy of 6th and 8th graders (McBeth et al. 2008; McBeth and Volk 2009). The instrument included the students' demographic background, environmental knowledge, attitudes, behavior, sensitivity, and relationship with nature. The instrument was later applied also in other countries, including the Czech Republic (Svobodova and Kroufek 2018; Svobodova 2021; Svobodová and Chvál 2022).

Other authors created their own instruments for analyzing the environmental literacy of selected groups. Szczytko et al. (2018) designed the ELI-A (Environmental Literacy for Adolescents) instrument monitoring environmental knowledge, hope, skills, and behavior (Szczytko et al. 2018). Goldman, Pe'er and Yavetz (2015) came up with an instrument consisting of subjective knowledge of environmental issues, environmental attitudes (grouped as concern for the environment, self-efficacy, importance of environmental education, and value of nature), verbal commitment to environmentally supportive actions, self-reported environmentally responsible behavior, and background data. Roczen et al. (2013) constructed a holistic model by integrating (reported) behavior, attitudes, and three different kinds of knowledge (system, action-related, and effectiveness knowledge).

In summary, regardless of their variety, models for measuring environmental literacy mainly rely on a combination of environmental knowledge tests, scales for environmental attitudes, values and beliefs, and self-reported behavior.

The influence of environmental and sustainable education on environmental literacy

The concept of environmental literacy has been repeatedly used to assess the impact of various ESE programs, including long-term school ESE projects, residential programs, non-formal education programs, and university programs (Hsu 2004; Spinola 2016; Szczytko et al. 2018). For instance, when monitoring eco-schools in a Belgium study, Boeve-de Pauw and van Petegem (2011) reported a moderate increase in attitudes and knowledge, besides confirming the scales' validity.

In Erdogan's (2015) study, the investigated program seemingly increased environmental knowledge, sensitivity, attitudes, and behavior, while cognitive skills remained unaffected. Baierl et al. (2021a) examined the role of motivation and fascination in the learning during a half-day outreach program, finding substantial knowledge gains and positive effects of motivation and fascination on knowledge. Furthermore, based on a sample of 6,585 children over a 9-year time span, when monitoring a three-day outdoor earth education program, Baierl, Johnson, and Bogner (2021b) described a positive effect of the program on pro-environmental attitudes and behavior.

In some cases (Spinola 2015), however, the program's effects seemed rather moderate or even non-detectable (e.g. Dieser and Bogner 2017). Regarding behavioral impacts, when evaluating a non-formal education program, Culen and Mony (2003) found no effect, but reported positive effects on participants' environmental literacy, including environmental knowledge and perceived action skills. Mixed effects of non-formal programs on environmental literacy were also reported by Goldman and colleagues (2013). Recently, similar approaches have emerged, such as the concept of sustainability consciousness, and these have been used to assess the effectiveness of selected ESE-teaching strategies (Olsson, Gericke, and Chang Rundgren 2015; Boeve-de Pauw et al. 2015).

For our understanding of instructional strategies promoting environmental literacy, the currently available impact assessment of ESE programs may not yet be sufficient, although there are several studies that analyzed instructional strategies. For instance, for students from schools using hands-on activities (such as experiments and investigation), Coertjens et al. (2010) reported higher environmental attitudes compared to others. Olsson, Gericke, and Chang Rundgren (2015) and Boeve-de Pauw et al. (2015) analyzed the impact of ESE strategies in Swedish secondary schools by monitoring the level of the students' sustainability consciousness and their perceived

level of implementation of holistic approaches (offering various perspectives on a particular phenomenon) and pluralistic approaches (engaging different perspectives and values). Neither the holistic nor the pluralistic approaches were found to be part of the practice in the classrooms. The relationship of both of these types of approaches with the students' sustainability consciousness was relatively modest, while the applied holistic approaches significantly predicted the students' sustainability knowledge and the pluralistic approaches the students' sustainability-focused behavior.

Dealing with the effects of cognitive learning in outdoor settings, Behrendt and Franklin (2014) summarized the advantages of hands-on learning by focusing on cognitive and motivational skills. When based on these skills, outdoor learning substantially strengthens knowledge acquisition. Liefländer et al. (2013) argued that outdoor learning deepens observation skills and thus strengthens inclusion in nature. According to Palmberg and Kuru (2000), outdoor learning fosters the human-nature relationship and students' awareness of environmental/ecological issues. The positive effects of outdoor settings on participants' connectedness to nature, environmental attitudes, and their pro-environmental behaviors have been reported also by other authors (Bogner 1998; Ballantyne and Packer 2002; Pirchio et al. 2021).

Other studies investigated the importance of the emancipatory approach, i.e. the approach which encourages students to participate in decision making about their learning objectives and activities (Wals et al. 2008). Cincera and Krajhanzl (2013) found a positive effect of the emancipatory approach on students' action competence and Cincera et al. (2019) reported a positive effect of the emancipatory approach on students' empowerment in the EcoSchool program. Other positive effects were found for programs engaging students in community-based projects. Ceaser (2012) reported positive effects on students' empowerment and pro-environmental behavior, and Ernst and Monroe (2004) on students' self-efficacy.

While the level of the impact of ESE strategies is still a matter under investigation, Sinakou et al. (2019) designed a model defining a sound practice for education for sustainable development (ESD). Based on this model, sustainability-focused education should be holistic, pluralistic, and action-oriented. The action-oriented aspect was further elaborated to include five interconnected components: action-taking, students' leadership, peer interaction, community involvement, and interdisciplinarity. Similarly, our study focuses on some of the components defined in this model, i.e. on the holistic approach, community involvement, and students' leadership. Based on this, our study's broader aim is to provide additional evidence that would contribute to the effort to define a sound ESE practice.

In consequence, our research questions were threefold:

- How is environmental literacy affected by selected ESE strategies in residential outdoor environmental education programs, school eco-club programs, or membership in nature-oriented non-formal-education youth clubs?
- What influence do different school ESE approaches (holistic, emancipatory, community-based), as perceived by the students, have on environmental literacy of Czech teenagers?
- What effect do demographic variables (gender, age) have on environmental literacy of Czech teenagers?

Methods

Project framework

This study is the output of an extensive nation-wide project focused on a representative survey of Czech secondary school students (6th, 8th, and 9th grades). The project's aims were to a) design a set of national guidelines for assessing environmental literacy of Czech primary school

students, b) investigate the level of the selected components of environmental literacy in a representative sample of Czech students, c) analyze the effect of the selected ESE teaching strategies on students' environmental literacy.

The first output of the project was the formulation of national guidelines, called MEG – Metodika pro vyzkum Environmentalni Gramotnosti [Guidelines for Environmental Literacy Assessment] which included an instrument for assessing environmental literacy and instructions for the instrument's implementation (Cincera and Kroufek 2021). This instrument was extensively discussed in the Czech professional community. To assess the instrument's validity, we organized a focus group with ESE experts ($N = 8$) and shared the instrument's first draft among the Czech and Slovak professional network CeSFER (we received comments from $N = 22$ national experts). Various parts of the instrument were (in gradually modified versions) piloted four times in two primary schools.

In the next step, the instrument was applied in a national representative survey. This study presents part of the findings focusing on the analyses of the effect of the selected ESE strategies.

Selection of instruments

The instrument followed Hollweg's et al. (2011) definition of environmental literacy and focused on environmental knowledge, attitudes, beliefs, and self-reported behavior. Except for the Environmental Knowledge test, all the scales consisted of a set of Likert-based scales (*strongly disagree – disagree – I do not know what to choose – agree – strongly agree*).

Values and attitudes scale

The scale was based on the 2-MEV model (Bogner and Wiseman 1999, 2002, 2006) which, besides bi-national validation studies within Europe (e.g. Bogner and Wiseman 1997), was independently confirmed in New Zealand samples by Milfont and Duckitt (2004), U.S. samples by Johnson and Manoli (2008), African samples by Borchers et al. (2013), and Asian samples by Liu and Chen (2019). The applied version was based on adjustment to the 2-MEV model for emotional appreciation of nature (Bogner 2018).

The scale consisted of three subscales:

- Preservation scale expressing students' biocentric values (9 items, Cronbach alpha ranging from .70 for the 6th grade to .77 for the 9th grade);
- Utilization scale expressing students' anthropocentric values (7 items, Cronbach alpha ranging from .68 for the 6th grade to .70 for the 9th grade); and
- Appreciation of Nature scale expressing students' affinity with nature (5 items, Cronbach alpha ranging from .80 for the 6th grade to .83 for the 9th grade).

In addition, the instrument contained a Place Attachment scale expressing students' emotional connectedness to their community (first used in Cincera, Johnson, and Kovacikova 2015). The instrument applied a 7-item Likert-based scale, Cronbach alpha ranging from .79 for the 6th grade sample to .86 for the 9th grade sample.

Environmental knowledge

The Environmental Knowledge test was derived from a concept used in Roczen et al. (2013) and Frick, Kaiser, and Wilson (2004) for monitoring three different kinds of knowledge (system, action-related, and effectiveness knowledge). The test's validity was confirmed by a group of external experts. The test assessed students' knowledge of ecological concepts (energy flow), their knowledge of environmental issues (climate change), and their action knowledge. It consisted of

a 32-item multiple-choice test, with each item offering three incorrect options and one correct option (Cronbach alpha = .67). For organizational reasons (the allocated time for data collection in 6th and 9th grades), the test was applied for respondents from the 8th grade only.

Beliefs

In accordance with Szczytko et al. (2018) and Goldman, Pe'er and Yavetz (2015), the model focused on the students' perceived capacity to positively promote the environment (here as 'locus of control'). The Locus of Control scale consisted of a 4-item Likert-based battery (Cronbach alpha ranging from .64 for the 6th grade to .68 for the 9th grade) and was adapted based on Powell et al. (2011).

Behavior

The scale for self-reported behavior was influenced by Kaiser's (1998) General Ecological Behavior scale which, apart from independent confirmations, was adjusted to adolescents (Kaiser, Oerke, and Bogner 2007). In the model it was defined as students' direct and indirect environmentally relevant behavior (switching off lights, recycling, persuading others to help the environment) and it was assessed by a 10-item Likert-based instrument (Cronbach alpha ranging from .78 for the 9th grade to .80 for the 6th and 8th grades).

ESE strategies

The second part of the model was inspired by Olsson, Gericke, and Chang Rundgren (2015), Boeve-de Pauw et al. (2015), and the authors' previous research (Cincera et al. 2019). It focused on selected ESE approaches and consisted of two sections:

The first section dealt with students' experience with environmental programs (for instance, as members of school eco-teams or environmental school clubs) and their participation in residential outdoor environmental education programs.

The second section dealt with perceived ESE teaching strategies (for instance, student reflection on their experience with selected teaching strategies). All of the strategies corresponded with the conceptual framework for ESD suggested by Sinakou et al. (2019). The instrument was inspired by Boeve-de Pauw et al. (2015) and is supposed to monitor three specific strategies (for the scale, see Appendix):

- The Emancipatory Approach, i.e. students' perceived opportunity to participate in decision making and to discuss environmental issues in their classes (7 items, Cronbach alpha ranging from .73 for the 6th grade to .78 for the 9th grade);
- The Holistic Approach, i.e. students' perceived opportunity to reflect on environmental issues from different perspectives and to draw various interconnections (3 items, Cronbach alpha ranging from .69 for the 6th grade to .77 for the 9th grade); and
- The Community-Based Approach, i.e. students' perceived opportunity to study environmental topics outdoors and by engaging with real-world, community-based issues (3 items, Cronbach alpha = .61 for all of the groups).

Demographics

In addition, students were asked to indicate their gender, age, type of school, the size of their community, and their region.

Sampling strategy

The sampling strategy differed for the 8th-grade students on the one hand and for the 6th- and 9th-grade students on the other hand. For the 8th-grade students, a stratified sample of 641

Czech schools was selected. The stratification reflected a) the region, b) the type of school (public or private), c) the expected number of students in the school, and d) the size of the community. In each of the schools, one class of 8th graders (M_{age}=13.4 years) was involved. In total, data from a representative sample of N = 21,518 students (approximately 25% of total population) were collected.

For organizational reasons, this procedure could not be applied for the 6th- and 9th-grade students. Here, we cooperated with Czech School Inspectorate, an institution managed by the Ministry of Education, Youth, and Sports, which collected the data as part of their annual inspection activities. They were supposed to visit approximately 300 schools during the school year (2019/2020). However, the process of data collection was affected by the outbreak of the COVID-19 pandemic and the lockdown of schools. As a result, only about half of the schools were visited, including N = 3,773 respondents from the 6th grade and N = 4,368 from the 9th grade.

The research was approved by the Ethics Committee of the Faculty of Education, Jan Evangelista Purkyne University under the reference number 4/2020/06. The Committee did not find any conflicts with valid principles, regulations and international guidelines for research involving human participants.

Data analyses

The values on the Likert-scale type variables were coded from 1 (*strongly disagree*) to 5 (*strongly agree*). The variables expressing the students' experience with various types of ESE programs were coded as yes/no/I do not know (the respondents who reported 'I do not know' were omitted from the analyses). On the knowledge test, students obtained 1 point for each correct answer and 0 points for any incorrect answer. Altogether, they could score 0-32 points on the knowledge test.

To analyze the obtained data, regression analyses and a t-test for comparing students according to their gender, participation in a residential program, and membership in an eco-club were used. For a comparison of more than two groups, One-way ANOVA was used. Because of the large sample, only p<.001 was considered as statistically significant. Effect size for t-test was calculated using Cohen's d (small effect = 0.2, average effect = 0.5, large effect > 0.8), for ANOVA test using η^2 (small effect = 0.01, average effect = 0.06, large effect > 0.14) (Cohen 1992).

Results

The effect of demographic variables on environmental literacy

Overall, the levels of environmental literacy of all of the investigated variables were considerably high, with minor differences among the analyzed groups. Both the students' gender and their age have a significant effect on most of the investigated variables. While boys reported a higher level of environmental knowledge (8th grade only) and place attachment, girls reported a higher level of pro-environmental values and behavior. Girls also reported a lower level of anthropocentrism (utilization of nature) than boys (see Table 1). Based on effect size, gender has the largest effect on appreciation and preservation of nature.

Additionally, younger students (6th graders) reported stronger pro-environmental attitudes and behavior than older students (see Table 2).

A subsequent Sheffe's post-hoc test showed significant differences (p < 0.001) between all groups within each variable except for 6th and 9th grade for Utilization, and 8th and 9th grade for Appreciation and Locus of control.

Table 1. The effect of gender on students' environmental literacy.

	6th Grade						8th Grade						9th Grade					
	M	SD	M	SD	t	ES	M	SD	M	SD	t	ES	M	SD	M	SD	t	ES
Variable	Girls		Boys				Girls		Boys				Girls		Boys			
Knowledge							18.17	4.12	18.48	4.34	−5.29	−.08						
Preservation	4.22	.50	3.96	.60	14.48	.47	4.01	.57	3.67	.69	40.56	.55	3.98	.57	3.5	.68	24.83	.76
Appreciation	4.06	.84	3.45	.99	20.12	.66	3.8	.94	3.13	1.04	49.8	.69	3.91	.90	3.07	1.02	28.8	.88
Utilization	2.27	.69	2.5	.72	−9.92	−.32	2.17	.68	2.44	.76	−27.95	−.34	2.21	.64	2.57	.72	−17.34	−.53
Locus of control	3.92	.67	3.7	.77	9.49	.31	3.66	.75	3.46	.87	18.44	.26	3.64	.74	3.39	.83	10.39	.32
Place attachment	4.3	.64	4.22	.67	3.5	.11	3.88	.84	3.95	.82	−6.38	−.09	3.91	.84	4.03	.79	−4.38	−.13
Behavior	3.61	.71	3.32	.77	11.89	.40	3.22	.75	3.03	.81	17.45	.24	3.16	.71	2.86	.72	14.17	.43

Note: $p<.001$ for all of the differences. "ES"=effect size, Cohen's d

Table 2. The effect of age on students' environmental literacy.

	6th Grade (N = 3773)		8th Grade (N = 21518)		9th Grade (N = 4368)			
Variable	M	SD	M	SD	M	SD	F	ES
Preservation	4.09	.57	3.84	.65	3.74	.67	341.41	.023
Appreciation	3.76	.96	3.46	1.05	3.49	1.05	133.60	.009
Utilization	2.38	.72	2.31	.73	2.39	.71	31.81	.002
Locus of control	3.81	.73	3.56	.82	3.52	.79	175.56	.012
Place attachment	4.26	.66	3.92	.83	3.97	.82	286.40	.019
Behavior	3.47	.75	3.12	.79	3.01	.73	396.50	.026

Note: $p<.001$ for all of the differences. "ES"=effect size, η^2

The effect of ESE strategies on environmental literacy

Students' participation in a residential outdoor environmental education program had a significant effect on most of the components of environmental literacy for all of the analyzed grades as compared to students who did not indicate having participated in such a program. The largest effect was on pro-environmental behavior (see Table 3). A similar effect was found for students' participation in a school eco-club and for their membership in a nature-oriented non-formal-education youth club as compared to non-members (see Tables 4 and 5). For a school eco-club, the largest effect was on locus of control and pro-environmental behavior; for a non-formal education youth club, the largest effect was calculated for appreciation of nature and pro-environmental behavior.

Generally, students reported that their school ESE tends to apply the emancipatory approach and the holistic approach, while the community-based approach remained rather rare. The 6th graders perceived their ESE as more emancipatory, community-based, and holistic than the 9th graders (see Table 6). A subsequent Sheffe's post-hoc test showed significant differences ($p<0.001$) between all groups within each variable except for the sixth and eighth graders in the holistic approach.

Regarding the approaches applied in teaching environment-related topics in school, their effect on most of the investigated components of environmental literacy seems to be significant but marginal.

However, we found a moderate effect of the perceived emancipatory approach on the level of students' locus of control and pro-environmental behavior. The community-based approach seemed to have a moderate effect on students' pro-environmental behavior (see Table 7).

Discussion

Limitations

The analysis of students' experience with ESE is based on self-reporting. The complex survey design did not allow us to collect additional data, for instance about the length, content, or nature of the analyzed strategies. As a result, the analysis does not differentiate among various forms of their implementation. While this approach is often used in similar studies (Olsson, Gericke, and Chang Rundgren 2015; Boeve-de Pauw et al. 2015), the findings should not be interpreted as a validation of *any* form of implementation of the analyzed strategies, but rather as a general tendency.

Additionally, the study is based on the assumption that the investigated strategies (i.e. students participate in various projects investigating community-based sustainability issues, often learn outdoors, participate in decision making about their learning, analyze sustainability topics from different perspectives, are members of an eco-team, or participate in residential outdoor environmental education programs) indicate a sound ESE practice. However, other relevant strategies may have been unintentionally omitted from the investigation. Based on this, the study cannot aspire to analyze the impact of all ESE approaches on students' environmental literacy, beyond the scope of the strategies specified.

Table 3. The effect of participation in a residential outdoor environmental education program on students' environmental literacy.

	6th Grade						8th Grade						9th Grade					
Variable	M_{yes}	SD	M_{no}	SD	t	ES	M_{yes}	SD	M_{no}	SD	t	ES	M_{yes}	SD	M_{no}	SD	t	ES
Knowledge	–		–		–		18.39	4.44	18.32	4.19	0.96	−.02	–		–		–	
Preservation	4.24	.51	4.03	.58	10.75*	.39	4.04	.59	3.79	.66	22.85*	.40	3.93	.60	3.70	.68	8.01*	.35
Appreciation	4.02	.85	3.65	.99	11.02*	.40	3.79	.95	3.38	1.05	22.71*	.39	3.78	.96	3.44	1.10	7.68*	.33
Utilization	3.68	.70	3.59	.72	3.27*	−.12	3.75	.77	3.68	.72	5.88*	−.10	3.74	.69	3.59	.71	4.78*	−.21
Locus of control	4.04	.65	3.72	.74	12.64*	.46	3.87	.75	3.49	.82	26.93*	.47	3.82	.72	3.46	.79	10.65*	.46
Place attachment	4.33	.63	4.23	.67	4.42*	.16	4.01	.81	3.90	.84	7.57*	.13	4.09	.82	3.95	.82	3.84*	.17
Behavior	3.76	.69	3.34	.74	16.10*	.58	3.52	.77	3.02	.76	37.44*	.65	3.36	.73	2.94	.72	13.61*	.58

Note:
*$p<.001$.
"ES"=effect size, Cohen's d

Table 4. The effect of participation in a school eco-team or any other environmentally focused school club on students' environmental literacy.

	6th Grade						8th Grade						9th Grade					
Variable	M_{yes}	SD	M_{no}	SD	t	ES	M_{yes}	SD	M_{no}	SD	t	ES	M_{yes}	SD	M_{no}	SD	t	ES
Knowledge	–		–		–		17.67	4.83	18.36	4.20	−5.35*	−.17	–		–		–	
Preservation	4.33	.49	4.08	.57	7.14*	.46	4.01	.65	3.83	.65	9.13*	.28	3.90	.66	3.73	.67	3.18*	.26
Appreciation	4.07	.84	3.73	.97	5.47*	.35	3.80	.94	3.44	1.05	11.27*	.35	3.79	.93	3.48	1.05	3.73*	.30
Utilization	3.63	.79	2.81	.71	0.22	−.01	2.84	.86	2.87	.73	−1.86	.06	2.88	.72	2.81	.71	1.68	−.14
Locus of control	4.15	.63	3.79	.73	7.76*	.50	3.96	.76	3.54	.82	16.72*	.52	3.83	.75	3.50	.79	5.07*	.41
Place attachment	4.31	.61	4.26	.66	1.18	.08	3.97	.84	3.91	.83	2.05	.06	4.01	.86	3.97	.82	0.56	.05
Behavior	3.94	.70	3.42	.75	10.80*	.70	3.62	.79	3.09	.78	22.03*	.68	3.31	.77	2.99	.73	5.36*	.44

Note:
*$p<.001$.
"ES"=effect size, Cohen's d

Table 5. The effect of membership in a nature-oriented non-formal-education youth club on students' environmental literacy.

	6th Grade						8th Grade						9th Grade					
Variable	M_{yes}	SD	M_{no}	SD	t	ES	M_{yes}	SD	M_{no}	SD	t	ES	M_{yes}	SD	M_{no}	SD	t	ES
Knowledge							18.12	4.44	18.66	4.09	9.00*	−.13						
Preservation	4.26	.54	4.07	.57	6.60*	.34	3.89	.63	3.75	.67	15.60*	.22	3.92	.61	3.72	.67	5.70*	.31
Appreciation	4.09	.84	3.71	.97	7.75*	.40	3.55	1.03	3.31	1.06	16.12*	.23	3.87	.92	3.45	1.05	7.36*	.40
Utilization	3.72	.77	3.61	.71	3.06*	−.16	2.32	.75	2.29	.71	2.97	.04	3.82	.67	3.59	.71	5.80*	−.31
Locus of control	4.02	.68	3.78	.73	6.41*	.33	3.64	.81	3.44	.83	17.82*	.25	3.75	.72	3.49	.79	6.16*	.33
Place attachment	4.31	.64	4.25	.66	1.61	.08	3.95	.82	2.86	.84	8.15*	.11	4.15	.72	3.95	.83	4.43*	.24
Behavior	3.86	.67	3.48	.75	11.77*	.61	3.22	.79	2.98	.77	22.20*	.31	3.39	.70	2.97	.72	10.73*	.58

Note:
*$p<.001$.
"ES"=effect size, Cohen's d

Table 6. The differences in perceived frequency of ESE-related approaches between the 6th, 8th, and 9th Grades.

	6th grade		8th grade		9th grade			
	M	SD	M	SD	M	SD	F	ES
Emancipatory approach	3.62	.70	3.52	.75	3.36	.79	128.59	.009
Holistic approach	3.64	.84	3.67	.90	3.56	.98	28.96	.002
Community-Based approach	2.74	1.00	2.56	1.02	2.44	.99	92.75	.004

Note: $p<.001$ for all of the differences. "ES"=effect size, η^2

Table 7. Multiple regression analyses for the effect of ESE teaching strategies on environmental literacy of 8th-grade students.

	R^2	Emancipatory approach (β)	Holistic approach (β)	Community-based approach (β)
Knowledge	.01	−.04*	.12*	−.06*
Preservation	.12	.19*	.17*	.06*
Appreciation	.10	.17*	.15*	.08*
Utilization	.01	−.006	.12*	−.09
Locus of control	.20	.26*	.13*	.16*
Place attachment	.05	.15*	.08*	.05*
Behavior	.24	.24*	.14*	.24*

Note:
*$p < .001$.
R^2=proportion of variance of dependent variable explained by the independent one. β = the degree of negative (-) or positive (+) change in the outcome variable for every unit of change in the predictor.

Despite the relatively large number of respondents, the research has its methodological limitations. For some of the variables, the level of Cronbach alpha declined slightly below the recommended level of .70, indicating possible problems with internal consistency. The strategy used for sampling of the 6th and 9th graders was affected by the pandemic situation, which has made the samples less representative and their comparison with the 8th graders less credible. For organizational reasons, the knowledge test was applied only for the 8th graders.

The effect of demographic variables on environmental literacy

In our study gender and age predict environmental literacy according to the existing results of literacy research (Goodale 2021; McBeth et al. 2008, 2011; Negev et al. 2008; Nurwaqidah, Suciati, and Ramli 2020; Özer-Keskin and Aksakal 2020; Svobodova 2020; Tuncer Teksoz et al. 2013). This coincidence despite different scales used in different cultures is promising (Negev et al. 2008; Kroufek, Çelik, and Can 2015, Kroufek et al. 2016).

Our study supports the existence of an 'adolescent dip', as reported by Olsson and Gericke (2015) or Baierl, Kaiser, and Bogner (2022). In line with earlier studies (McBeth et al. 2008; Negev et al. 2008; Liefländer and Bogner 2014; Svobodova 2020), it may indicate the developmental tendency of teenagers to focus on their relationships with their peers instead of their initial genuine interest in nature and environmental issues. Secondarily, this phenomenon may also indicate the relative failure of ESE that seems unable to meet this challenge by employing an age-appropriate learning strategy. However, both interpretations reflect a gap between older students' needs and ESE teaching.

Implications for ESE practice

Overall, the importance of ESE for developing students' environmental literacy is apparent. It shows that students' participation in residential outdoor environmental education programs and

their engagement in a school eco-club or in a nature-oriented non-formal-education youth club has a certain effect on students' environmental attitudes and behavior. However, these findings must be interpreted in light of the study's limitations. First, while the differences between the participating and non-participating groups are significant, in most cases they seem rather moderate. It is likely that other factors, not investigated by this study, play a role as well.

Additionally, participation in a school eco-club or a nature-oriented non-formal-education youth club may influence students' initial motivation to deal with the environment and an associated higher level of pro-environmental attitudes. As Pelletier et al. (1998) and Boeve-de Pauw and van Petegem (2017) found, environmental attitudes and beliefs (locus of control) positively correlate with self-determined motivation. Based on Boeve-de Pauw and van Petegem (2017), the correlation between self-determined motivation and pro-environmental behavior seems to be more complex and rather modest as self-determined motivation may be hindered by perceived helplessness and paralysis (Sass et al. 2018). Based on this, assuming that students' voluntary activities represent their self-determined motivation to protect the environment, the higher level of their environmental literacy that was found may not necessarily be the result of their engagement in these activities.

Nevertheless, the findings, e.g. the positive effects of participating in a residential outdoor environmental education program, a school eco-club, or a non-formal-education youth club on students' environmental literacy found here seem to be in agreement with other studies (Culen and Mony 2003; Erdogan 2015; Krnel and Naglic 2009; Spinola 2015).

The applied ESE strategy seems to have a marginal effect on most of the components of environmental literacy. This is similar to the findings by Olsson, Gericke, and Chang Rundgren (2015) who found only a limited effect of ESD implementation on students' sustainability consciousness. However, for the students' locus of control and pro-environmental behavior, we may assume that particularly the emancipatory and community-based approaches play a meaningful, if only a moderate role. Here, the study corresponds with the findings of other authors (Ceaser 2012; Boeve-de Pauw et al. 2015; Cincera et al. 2019). Based on this, both approaches seem to be sound and worthy of support in ESE-related pedagogy.

It is also clear that even though none of the approaches (and particularly not the community-based approach) is very common in Czech schools, they are not completely unknown. These findings resonated with a previous survey of ESE strategies applied in Czech schools which revealed that less than 20% of Czech secondary schools involve students in investigating local sustainability challenges or in other such actions. A similar proportion of schools allowed students to participate in decision making in ESE projects (Činčera et al. 2016).

This seems to correspond with the levels of perceived holistic and pluralistic ESE teaching in other countries, e.g. in Swedish schools, as reported by Boeve-de Pauw et al. (2015) or Borg et al. (2012). As in the findings in Boeve-de Pauw et al. (2015), the holistic approach seemed to be more widespread than the other investigated approaches.

Based on this, we may assume that there is a need to increase support for these strategies also beyond the Czech Republic. Better understanding of their potential and limitations may be a step into this direction.

The implications for ESE policy

While the present study focused more on the results than on the instrument, the applied methodology may be potentially important for the development of ESE in the Czech Republic. It was the first time that a representative survey of students' environmental literacy has been conducted in this country and the findings may become a 'benchmark' for further, follow-up surveys planned in the coming years.

This effort would not be possible without the interest of government bodies in an evidence-based policy. From this perspective, the research may be seen as a positive example of cooperation between political decision makers and the research community.

On the other hand, the study also opens several specific questions. The findings could be both used and misused, either as a basis for a well-targeted support of ESE or as an argument that such support is not needed. While we agree with Laessøe, Feinstein, and Blum (2013) that the involvement of researchers in policy making may be risky, we also believe in the necessity of such cooperation. We hope that this study provides evidence that this cooperation is both possible and mutually beneficial.

Recommendations for ESE theory and practice

In light of the importance of supporting emancipatory and community-based approaches in ESE practice, our study has opened space for further recommendations. One recommendation is related to teachers' competence for ESE – teachers' lack of such competence may be the main barrier to successful ESE implementation (Borg et al. 2012). To develop teachers' competence for participatory or community-based teaching, it is necessary to reconsider how the pre-service and professional development programs work and what kind of support teachers need. The relatively modest effect of ESE on students' environmental literacy may indicate that a) there still are existing limitations in differentiating the variety of implementation strategies, and b) there are other (hidden) factors which are also important.

Additionally, the 'adolescent dip' may indicate the lack of age-appropriate ESE strategies for older students. It would be highly beneficial to focus on the way ESE is implemented and identify what a more effective ESE may look like for this age category. It is interesting to note that not only the students' environmental literacy, but also the reported application of emancipatory and community-based approaches decreases with age. Based on the research design, it is not clear whether this indicates that these strategies are less frequently used by teachers in the higher grades or whether they are only perceived by the students – who might appreciate them more – as being less frequently used.

Conclusions

Based on the study, engaging in environmental and sustainable education produces a slightly higher level of environmental literacy, including fostering pro-environmental behavior, attitudes, and locus of control. In addition, when students feel that they have a chance to participate in decision making in their environmentally focused curricula and if their environmental learning reaches beyond the world of their school to connect with their community and the outdoors, they are rating higher their capacity to do something positive for the environment. At the same time, the effects of ESE on students' environmental literacy were relatively small. This may indicate the importance of other factors.

In comparison to ESE, students' age and gender seem to be more influential. Boys tend to know more about the environment than girls, but girls reported stronger bio-centric values than boys and inclination to act pro-environmentally. Younger students showed stronger pro-environmental values and behavior than older students. Thus the study prepared a basis for future surveys on both regional and national levels that will be able to analyze the trends in environmental literacy and the effectiveness of ESE policies.

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Appendix: The scales for perceived ESE teaching strategies

The Emancipatory Approach

- As students, we are allowed to suggest to our teachers what environmental topics we could learn about.
- At school, we can participate in various projects that allow us to contribute to improving the environment.
- When we work on an environmental project at school, we are allowed to choose a solution procedure we think is best.
- I believe that I have opportunities to make decisions that influence what and how we learn about the environment at school.
- When we learn about environmental issues, we always investigate them from various perspectives.
- When we read about the environment at school, we usually critically discuss the text.
- When we discuss the environment, everyone has the right to express their own opinion.

The Holistic Approach

- When we learn about the environment, we always connect what is now with what was in the past and what may happen in the future.
- When we learn about global issues, we always also learn about how they may be connected with what is going on at home.
- When we learn about environmental issues, we discuss how they are connected with the economy and with the problems of ordinary people.

The Community-Based Approach

- I have been involved in a project at school in which we helped to improve something in our community.
- We often learn outdoors at school.
- We are involved in a project aimed at helping other people or the environment.