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The effectiveness of education for sustainable development revisited – a longitudinal study on secondary students' action competence for sustainability

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ABSTRACT

This study revisits the seminal question of the effectiveness of education for sustainable development (ESD) by using a novel longitudinal approach. Scholarly attention in the past decade has been increasingly directed towards the concept of action competence for sustainability. However, little is still known about the effects of ESD as a teaching approach to help develop students' action competence for sustainability. This study therefore adopts a three-wave longitudinal design, tapping into the development of 760 Swedish upper secondary students' self-perceived action competence for sustainability as related to their experience of ESD teaching at their school. We can conclude that ESD has effect on students' action competence for sustainability. Our longitudinal growth models show that it is possible to develop students' action competence, which is affected by their experience of ESD teaching at their school. However, the students did not significantly develop the action competence component confidence under their own influence. Our findings reveal that developing students' action competence by implementing ESD in formal education takes time, and they shed light on the need for longitudinal research studies in the field of ESD.

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Effectiveness; education for sustainable development; holism and pluralism; action competence; growth modeling

Introduction

This study revisits the effectiveness of education for sustainable development (ESD). In a previous study, we investigated students' experience of ESD in terms of the teaching approaches of holism and pluralism. In that study, it was found that ESD has effect on students' knowledge about the prerequisites for sustainable development and on their self-reported sustainability behavior (Boeve-de Pauw et al. 2015). However, the integrated nature of today's sustainability issues, so-called super wicked problems (Lambrechts 2020), requires citizens to not only have knowledge and skills to display certain sustainability behavior, but also to have the competences to act upon these wicked problems. The focus of the educational outcomes that should be promoted in ESD has therefore shifted from the information-deficit model of education, towards sustainability competences (Redman, Wiek, and Redman 2018). As a consequence, scholarly attention in the past decade has been increasingly directed towards the concept of action competence for sustainability (Chen and Liu 2020; Varela-Losada et al. 2016). Our current study

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therefore aims to contribute more knowledge to the ESD research field by investigating the effectiveness of ESD on students' action competence for sustainability. Furthermore, instead of using a cross-sectional design, which for practical reasons is more common in ESD research, despite its limitations, this study adopts a longitudinal design, studying effects at the student level in an ESD school development project spanning more than two years. A longitudinal design that includes investigations of students' action competence for sustainability and their experience of ESD is a much needed innovation and contributes new and valuable information about the effectiveness of ESD to the research field.

Action competence-oriented education for sustainable development

Through ESD research and policy development, we know that teachers have an important task in organizing and conducting their teaching in such a way that students gain the knowledge, skills, and competences required to cope with sustainability issues (e.g. Rieckmann 2017). This means that the goal of ESD is not a 'mere' behavioral change among students, but rather a teaching and learning process where students' sustainability knowledge, skills, and competences are strengthened (Mogensen and Schnack 2010; Wals 2011). This kind of education, *education for sustainable development,* is described as a teaching approach where action competence for sustainability is at the very core of education (Hadjichambis et al. 2020; Mogensen and Schnack 2010; Rieckmann 2017; Sinakou et al. 2019). But what exactly does this mean for the teaching and learning practice?

According to research, action training is central when building action competence (Jensen 2002; Kollmuss and Agyeman 2002; Short 2009). One critical element in the promotion of action competence among students is the action-oriented experiences in the teaching, where students have the opportunity to work with authentic problems in a democratic and pluralistic way (Chen and Liu 2020). Such an approach is often referred to as a transformation of existing teaching and learning, since it represents a shift in our way of thinking, feeling, and acting on issues related to the environment and to sustainable development (Blythe and Harré 2020). To accomplish this shift in education and empower action competence among students, Sinakou et al. (2019) argue for an action competence-oriented ESD composed of action-orientation, holism, and pluralism.

Action-orientation, holism, and pluralism

Action-orientation involves taking action on real sustainability issues, students' leadership (which requires students to get actively involved and make decisions about their learning), and the interaction with peers and the surrounding community (Sinakou et al. 2019). The work in groups, with peers, and the collaboration with the surrounding community may also support students in the view that actions do not exclusively take place at the individual level, but also at the collective level. The interdisciplinary nature of actions in sustainability supports the development of students' understanding of how different disciplines contribute to the solutions (Sinakou et al. 2019; Varela-Losada et al. 2016). This leads us to one of the components in the action competence-oriented ESD, referred to as *holism*. This teaching component emphasizes multiple perspectives on the content and the importance of including the environmental, economic, and social perspectives of sustainable development, as well as their interactions in time and space (Boeve-de Pauw et al., 2015; Hopkins 2012). Interdisciplinarity could therefore become crucial when teaching is focused on the interrelationship between these perspectives. From a holistic perspective, this means that sustainability problems arise from conflicts of interest between environmental, economic, and social perspectives (Borg et al. 2014; Tilbury 2012). Not only do such conflicts of interest occur between individuals; they also extend to the societal level and incorporate the local perspectives with the global nature of sustainability issues together with

their past, present, and future implications (Atkinson, Dietz, and Neumayer 2007; Östman, Van Poeck, and Öhman 2019).

Another important action competence-oriented ESD component is referred to as *pluralism* and focuses on how to develop competences that enable students to make well-informed decisions in relation to sustainability issues (Sinakou et al. 2019). Pluralism could be seen as a collective and participatory approach where students are involved in discussions where different views and values are acknowledged in relation to the sustainability issue at hand. Öhman and Östman (2019, 80) describe the characteristics of pluralistic teaching as (1) a teaching approach where sustainability problems are dealt with democratically; (2) dealing with conflicts between humans; (3) critical discussions highlighting a number of alternatives; (4) a teaching approach where students train their ability to critically evaluate and take a stand on sustainability issues; (5) an approach where students train their competences as citizens to engage in real sustainability issues in society. In other words, pluralism embraces a democratic approach to teaching in which students will discuss and become aware of different perspectives and interests in society (Öhman and Östman 2019). However, discussing different perspectives and actions in the classroom will not automatically lead to real sustainability actions on behalf of the students (Manni and Knekta 2020).

Because of the wicked nature of sustainability issues, the pluralistic teaching is not directed towards a predefined solution, which thus highlights the need for a critical discussion of different perspectives on sustainability solutions in ESD teaching and learning (Boström et al. 2018; Öhman and Östman 2019). Such ESD teaching and learning approach is often referred to as transformative or transactional, or as social learning, and includes components such as critical thinking, a participatory (student-centered) approach, collective learning, multi-method approaches, decision-making, and/or value-based learning (Boström et al. 2018; Östman, Van Poeck, and Öhman 2019; Wals, 2009). The underlying idea is to train students to take action now, not only in the distant future, thereby strengthening their action competence for sustainability (Östman, Van Poeck, and Öhman 2019).

Sund (2016) showed that teachers struggle to change their existing teaching tradition from, for example, a fact-based or normative selective teaching tradition to a pluralistic and more action competence-oriented ESD. In the same way, Öhman and Östman (2019) conclude that it could be time-consuming and challenging to adopt a pluralistic teaching approach. Teachers have also been shown to encounter barriers in reorienting teaching and learning towards pluralistic ESD, interdisciplinarity being an example of such a barrier, (Borg et al. 2012). Given that the cultivation of action competence for sustainability includes the holistic and pluralistic idea of teaching and learning for sustainability (Chen and Liu 2020; Mogensen and Schnack 2010), it is important that students experience such teaching at their school. However, whether or not student experience of holism and pluralism have effects on ESD outcomes in terms of action competence still seems to be a missing piece in research.

Research has previously shown that experience of ESD teaching in terms of holism and pluralism has an impact on ESD outcomes, such as knowledge of the prerequisites for sustainability and self-reported sustainability behavior (Boeve-de Pauw et al. 2015). However, as far as we know, no studies have investigated the ESD development of students longitudinally over time, and its effect on the action competence of students. In this study, we therefore revisit the issue using a longitudinal study design.

Effectiveness of environmental and sustainability education and action competence for sustainability?

Several studies in the last decade have focused on gathering valid empirical evidence of the impact of environmental and sustainability teaching and learning on components of action competence in terms of cognitive, affective, and/or behavioral outcomes among students (e.g.

Berglund, Gericke, and Chang Rundgren 2014; Boeve-de Pauw and Van Petegem 2011, 2018; Boeve-de Pauw et al. 2015; Cincera and Krajhanzl 2013; Goldman, Pe'er, and Yavetz 2017; Johnson and Manoli 2010; Krnel and Naglic 2009; Liefländer and Bogner 2018; Negev et al. 2008; Olsson, Gericke, and Chang-Rundgren 2016; Zhan, He, and So 2019). In their review study, Ardoin and colleagues (2018) conclude that these kinds of studies typically show very limited effects on the behavioral outcomes (e.g. Krnel and Naglic 2009; Olsson, Gericke, and Chang-Rundgren 2016). Additionally, even though there is an effect on cognitive outcomes, it correlates with behavioral outcomes to a very low degree (e.g. Negev et al. 2008). In some cases, studies report improved pro-environmental attitudes (e.g. Johnson and Manoli 2010) and correlations between improved environmental knowledge and a shift towards more environmental preservation attitudes (e.g. Liefländer and Bogner 2018). Most of these studies are too narrow in their operationalization of ESD, given their use of school labels (e.g. eco-schools or green schools) or policy documents as a proxy for the quality of the ESD approaches in schools. Such an operationalization can be problematic since it does not serve as evidence for what has really taken place during the teaching; e.g. schools may have obtained an eco-school label but do not apply action-oriented teaching approaches. In a previous study, we therefore developed a more advanced study design by empirically investigating student' experience of ESD teaching in the form of holism and pluralism (Boeve-de Pauw et al. 2015). In that study we surveyed students' perception of the extent to which teachers in their school provide holistic and pluralistic teaching and the effects these perceptions have on their learning outcomes in relation to sustainable development – their sustainability knowledge and behavior (Boeve-de Pauw et al. 2015). Hence, in this study design, an empirical relationship is constructed between students' experience of teaching, and their learning outcome. In this study, we use the same study design.

A second problem is that most quantitative studies within ESD research apply a cross-sectional design or a comparison between an experimental group and a control group at a single moment in time (e.g. Boeve-de Pauw et al. 2015; Cincera and Krajhanzl 2013; Krnel and Naglic 2009; Olsson, Gericke, and Chang-Rundgren 2016). There is also a large proportion of intervention studies that include short-term pre- and post-tests (e.g. Johnson and Manoli 2010; Liefländer and Bogner 2018; Zhan, He, and So 2019). According to research review by Chen and Liu (2020) these study designs are problematic because they compare groups that differ in ways that cannot be controlled for, or the designs use time frames that are too narrow for follow-up tests. In this study, we address these issues by setting up a longitudinal study design where the same students are followed over the course of two school years.

A third problem is that researchers in environmental and sustainability education use very diverse interpretations of the action competence concept and its outcomes (Chen and Liu 2020; Sass et al. 2020). Recent efforts has therefore been made to redefine and identify the generic definition of the concept of action competence through the case of sustainability (Sass et al. 2020). In their work, Sass et al. (2020) define action competence as being able and having the competences to solve and act on problems based on intertwined perspectives (for example issues related to sustainable development). Furthermore, three main constructs are identified and defined for the action competence concept.

The first part of the construct definition includes *knowledge of action possibilities* and is related to knowledge and skills and critical reflection (Olsson et al. 2020; Sass et al. 2020). This means that students should have the competence to consider different dimensions (e.g. environmental, economic, and social) of sustainability issues and their possible solutions. Possible solutions incorporate a comprehensive knowledge base about the origin, cause, and effect of the issue at hand and the conflict of interest between stakeholders. The ability to critically reflect on and prioritize different possible solutions is therefore important for this first part of the action competence construct (Sass et al. 2020). The second part of the construct concerns the *willingness to act* – that is, the willingness to contribute to action. As such, an action-competent person wishes to take responsibility for themselves and for others through their actions. Sass

et al. (2020) argue that this part of the construct therefore encompasses the commitment and the passion for engaging in the explanations to others and to the solving of a sustainability issue. The third and final part of the action competence construct concerns the *confidence in one's own influence*. At the core of this part lies the self-efficacy of the students – primarily the efficacy expectations in terms of one's own capacities to contribute to change, but also in terms of outcome expectancy regarding one's own possibilities to be influential (Sass et al. 2020). This study includes the three constructs described above in a longitudinal design to contribute to cohesive and contemporary research on ESD effects on action competence outcomes at the student level.

Research aim and questions

Given the background outlined above, this study aims to investigate the effects of ESD on students' action competence for sustainability by taking a longitudinal approach. Students' experience of ESD is investigated in terms of holism and pluralism, using the same items as those presented in the study of Boeve-de Pauw et al. (2015). The outcomes of ESD at the student level are investigated using the concept of action competence and the questionnaire instrument of self-perceived action competence for sustainability (Olsson et al. 2020), which is an instrument adapted to the re-conceptualization of the action competence concept (Sass et al. 2020). By adopting a longitudinal design in which we followed a school development project with the intention of implementing ESD, we contribute a novel approach of investigating the effects of ESD at the student level. The following research questions guide the investigation, where the third could be seen as the overall research question:

1. What is the development of students' experience of the ESD teaching in terms of holism and pluralism?
2. What is the development of students' self-perceived action competence for sustainability in terms of their knowledge of action possibilities, confidence in one's own influence, and willingness to act?
3. What is the effect of ESD on students' self-perceived action competence for sustainability?

Method

For the present study, we adopt a longitudinal design to be able to investigate the overall aim and the specific research questions. This method section will in turn describe the context of the study, the study design and data collection, the scales used in the study, and finally the analytical approach.

The context – the municipality project

This study is part of a larger research project investigating the development of ESD in schools in a Swedish municipality. The municipality designed a teacher professional development program based on the model for effective teacher professional development (Desimone 2009) in which one of the main ideas was to develop action competence for sustainability among students based on ESD teaching. Two project leaders with more than 10 years of teaching experience at other schools in the municipality – themselves active ESD researchers (of which one is co-author of this article) – comprised the project management team and were employed by the municipality to implement the project. The teachers in the project schools were given the opportunity to develop their own ESD teaching competence and implement ESD in terms of

holism and pluralism (including action orientation) at their school, which in turn is hypothesized to result in a development of ESD learning outcomes and competences at the student level (Desimone 2009).

The present longitudinal study took place in one of the schools participating in this municipality school development project. The school is an upper secondary school with about 900 students. After compulsory school in Sweden (up to grade nine), almost all students continue to an upper secondary (grade 10–12) vocational or preparatory school program based on their interests. The school included in this study offers two theoretical programs. The students therefore attended either the science program or the technology program.

All the teachers and school leaders at this upper secondary school were active in the school development project. They participated in five full or half day seminars that were organized over two school years. During these seminars we engaged teachers with scaffolded ESD learning experiences. There were lectures, workshops and discussions related to ESD. Early in the school development project the seminars aimed to develop the holistic approach to teaching, including key competences for sustainability (see Rieckmann 2017) and teachers' knowledge and self-efficacy towards ESD. Towards the end of the project the seminars more directly focused on transforming the teaching approach at their school to become more cross-disciplinary, action oriented and pluralistic.

In between the seminars the teacher teams had regular meetings where they discussed issues related to the ESD development project, the teaching of the students and their development of action competence for sustainability. Two teachers at the school were appointed as facilitators to lead and assist the collegial work among the teachers. The two facilitators were allocated 20% each of their working hours for this task. To support the school development project further and to discuss ESD implementation opportunities and obstacles, the facilitators met with the project leaders three to four times each semester for a two- to four-hour meeting. The project leaders also met the school leaders once each semester to plan and discuss how to further enact the professional development program with the teachers.

The municipality project was conducted between early 2017 and late 2019. During this time our research team centered on adopting a longitudinal design which would make it possible to collect data and study effects of the ESD development process at different levels of the school organization (students, teachers, and school leaders) in line with the framework of Desimone 2009. In this study, in response to the argumentation for the need of more research investigating effects of school development processes at the student level (e.g. Desimone 2009; Wayne et al. 2008), we specifically collected longitudinal questionnaire data aiming to investigate the development of students' experience of ESD teaching and their ESD outcomes, in terms of their self-perceived action competence for sustainability. Furthermore, we investigated the effect of the students' experience of ESD teaching on their self-perceived action competence for sustainability.

Study design and data collection

Questionnaire data were collected in three waves at the student level at the upper secondary school and in accordance with a longitudinal design. The first wave took place in February 2018, the second wave in September 2018, and the final wave in April 2019. The students in this experimental group participated in one, two, or all three of the waves. The first wave included the students in grades 10 and 11 (17–18 years old) and these students were then followed through grades 11 and 12 (18–19 years old) in the second and the final wave. Data from a control group of students were collected from 11th and 12th graders in the same upper secondary school nine months ahead of the first wave for the experimental group. The control group of students thus did not participate in the longitudinal data collection, so as to enable cross-sectional control comparison between the students in the final wave and the students in

the control group. A cross-sectional comparison could indicate whether a development among students in the longitudinal design study is related to what students have experienced in the teaching they have received or is the result of a natural age-related development. A representation of the study design is shown in Figure 1.

In total 760 students participated in the three waves. However, a longitudinal design renders it almost impossible to have all the students participate in every wave. As a result, 208 students participated in all three waves, 240 students participated in two of the waves, and 312 students participated in one of the waves, see Table 1.

The students either attended the technology program or the science program. The control group had 228 participants – 147 students from the science program and 81 from the technology program. The sex ratio (girls/boys) for the control group was 0.59, similar to the sex ratio for the experimental group (0.57 in the third wave). The explanation for these differences is that the technology program generally speaking has more male than female students, while the opposite is true for the science program.

The number of students, sex ratio, and proportion of missing data can be found in Table 1.

The scales used in the study

Two scales were used to follow the students through the three waves in this study. First, the self-perceived action competence for sustainability scale (SPACS-scale), which was developed by Olsson et al. (2020) to measure the construct of action competence with reliability and validity. The scale consists of three sub-scales covering the constructs of knowledge of action possibilities (KAP), confidence in one's own influence (COI), and willingness to act (WTA). Each of the three sub-scales is covered by four items on the five-point Likert scale, ranging from 'totally disagree to totally agree'. Given the need for coherence in the use of action competence outcomes (Chen and Liu 2020), the three components of self-perceived action competence for sustainability are considered important outcomes among people in sustainability education (Olsson et al. 2020; Sass et al. 2020) and are therefore used for the investigations of learning outcomes in this longitudinal study. The items are specified in Appendix A.

Secondly, we used the ESD, holism, and pluralism scale (Boeve-de Pauw et al. 2015). The scale consists of seven items, where three items cover the students' experience of holism and four items cover the students' experience of pluralism in teaching (see Appendix A). The respondents marked their answers on a five-point Likert scale: (1) never, (2) seldom, (3) sometimes, (4) often, and (5) very often. A 'don't know' option was available. The following statement introduced the items in the survey: 'The following claims focus on your experiences in the

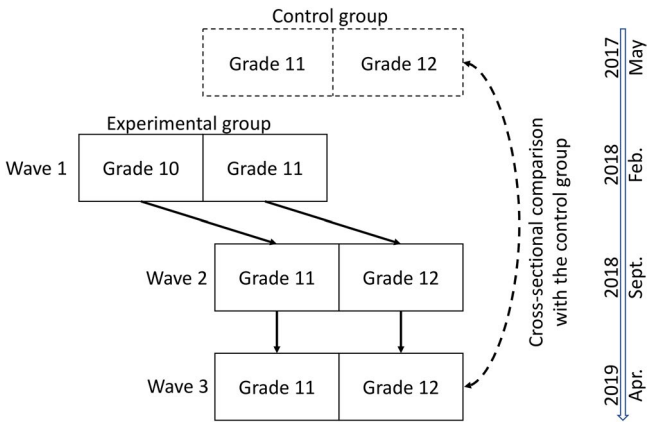

Figure 1. Data collection and study design.

Table 1. Number of participants, sex ratio, and missing data.

	Wave 1			Wave 2			Wave 3			Whole sample		
	Science	Technology	Total	Science	Technology	Total	Science	Technology	Total	Science	Technology	Total
Number of students	240	259	499	223	256	479	173	265	499	338	422	760
Sex ratio (girls/boys)	1.22	0.26	0.59	1.29	0.26	0.59	1.43	0.28	0.57	1.23	0.27	0.57
Missing data (%)			34.3%			37.0%			42.4%			37.9%

classroom'. The purpose of using this ESD scale is to longitudinally follow the effects on students' experience of the teaching as a result of the teachers' development of ESD teaching through the implementation process at the school. This is a novel approach since, to our knowledge, the SPACS scale and the holism and pluralism items have not yet been used in this kind of longitudinal design.

Data analysis and analytical approach

We applied latent growth modeling (LGM), which is an appropriate method of analysis for a longitudinal design including questionnaire data (Ferrer, Balluerka, and Widaman 2008). In LGM, the longitudinal component is added to the structural equation modeling (SEM) and confirmatory factor analysis (CFA) (Curran, Obeidat, and Losardo 2010; Duncan, Duncan, and Strycker 2013; Little 2013). In LGM, the intercept (the starting point) and the slope of the trajectories over time are introduced and represented as latent constructs (see Appendices B and C). In such a multiple indicator longitudinal approach, there is a need to establish a measurement equivalence between the different waves in the study, so-called measurement invariance. The process of establishing measurement invariance and the subsequent LGM can be seen as a five-step process where the first three steps are related to the CFA and the two last steps to the LGM (Kelloway 2014). To reduce the complexity in our analysis, we have investigated each of the subconstructs separately. Complexity reduction is relevant to the establishment of factorial invariance over time, since a 1st-order latent model and a more complex 2nd-order model would lead to roughly equal expected trajectories (Ferrer, Balluerka, and Widaman 2008). Multiple fit indices were used to evaluate the models, with the recommended values of .95 for the comparative fit index (CFI) and Tucker-Lewis index (TLI). Values ≤.06 were used for the root mean square error of approximation (RMSEA) (Tabachnick and Fidell 2007). The default estimator for this type of analysis, including categorical data, is a robust weighted least squares estimator (Muthén and Muthén 2017).

Missing data is a common issue in longitudinal research. This was also the case in our study (see Table 1). However, the default in the statistical software Mplus is to estimate the models under missing data theory using all available data (Muthén and Muthén 2017, 8). According to the significant ($p < 0.05$) Little's MCAR test (Missing Completely at Random) of our data, it is not likely that the data should be treated as MCAR. It is most likely that the missingness for our data is under MAR (Missing at Random), which means that missingness is allowed to be a function of the observed covariates, such as gender or educational program (Muthén and Muthén 2017). Hence, in the analysis of the different models and steps going forward, all respondents are used to estimate the models.

Confirmatory factor analysis and measurement invariance

Following the established convention of at least three waves in a longitudinal study (Kelloway 2014; Muthén and Muthén 2017), Figure 2 shows the hypothesized model for the four indicators of each of the latent constructs constituting self-perceived action competence for sustainability. The hypothesized model for the two ESD subscales (holism and pluralism) looks the same, but each model includes three indicators building up the latent construct instead of four.

The first step was a CFA estimation, after which equality constraints were imposed to establish measurement invariance between time points (Kelloway 2014). Therefore, in the second step, factor loading measurement invariance was estimated. In the third step, factor loading and threshold constraints were imposed to establish full measurement invariance. In Table 2, the fit indices for each step are presented for the latent constructs. If needed, modification indices with relevant covariances could be used to improve the model (Kelloway 2014; Muthén and Muthén 2017). However, we decided to not make any such sample-specific adaptions to the model, since the fit indices overall indicate models with good model fit (see Table 2) and the

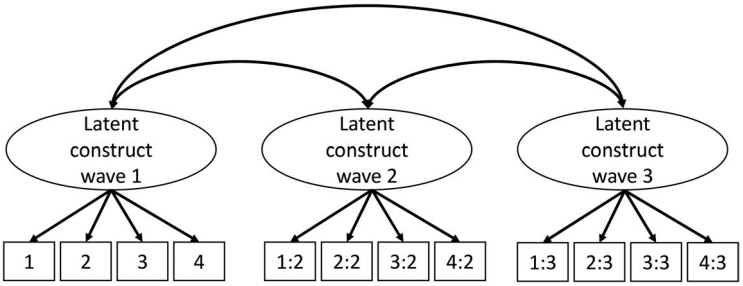

Figure 2. Hypothesized model for each of the latent constructs of knowledge of action possibilities (KAP), confidence in one's own influence (COI), and the willingness to act (WTA). For the latent constructs of holism and pluralism, there are three items in each wave.

Table 2. Fit indices for the three-step CFA measurement invariance procedure.

CFA	CFI	TLI	RMSEA	Pass?
KAP				
Step 1	.993	.991	.044	Yes
Step 2	.990	.989	.049	Yes
Step 3	.993	.991	.044	Yes
COI				
Step 1	.991	.989	.045	Yes
Step 2	.993	.992	.039	Yes
Step 3	.991	.989	.044	Yes
WTA				
Step 1	.985	.980	.067	Yes
Step 2	.985	.982	.064	Yes
Step 3	.984	.981	.066	Yes
Holism & Pluralism				
Step 1	.964	.955	.048	Yes
Step 2	.953	.944	.053	Yes
Step 3	.958	.950	.050	Yes

Note: KAP = knowledge of action possibilities, COI = confidence in one's own influence, and WTA = willingness to act. Step 1: no measurement invariance. WTA step 1.2: correlation between two items improved the model. Step 2: factor loading measurement invariance and step3: full measurement invariance (factor loading and intercept invariance).

third step (Step 3 in Table 2) of the CFA shows that there is full measurement invariance between the different time points in the study.

The CFA also showed that all items contribute to its respective factor in a good way (the factor loadings and structure for all scales can be seen in Appendix A), except for item number seven on the ESD scale (factor loading: below .45), which had a negative impact on establishing measurement invariance for this scale. Hence, one item – item number seven – on the ESD scale appeared to be problematic. In a control using exploratory factor analysis as preparation for the LGM, it loaded in both the holism and pluralism factor. All the other items ended up in their respective factors. We therefore decided to delete item number seven on the ESD scale (the fourth pluralism item) from further analysis so that three items each were used for the holism and pluralism scales in the confirmatory factor analysis and the subsequent LGM.

Data from the third wave were used for the SEM model and the investigations of the effect of students' experience of ESD in terms of holism and pluralism on their knowledge of action possibilities, confidence in one's own influence, and on their willingness to act.

Longitudinal growth models

The measurement invariant models from step 3 (see Table 2) were used for the LGM in step 4 (see Table 3). Given our categorical indicators, the measurement invariance was specified by maintaining the thresholds and factor loadings of the factor indicators equal over time (Muthén

and Muthén 2017, 139–140). The intercepts of the latent factors of knowledge of action possibilities, confidence in one's own influence, willingness to act, holism, and pluralism were fixed to zero as default in the parameterization of the growth model. Also, the mean of the intercept growth factor was fixed to zero by default in this LGM, while the mean of the slope factor, the variances, and the covariance of the growth factors were free to be estimated by default (see Muthén and Muthén 2017, 139–140).

The covariates of gender (girls and boys) and educational track (science or technology) were introduced into the model in the fifth and final step of the analytical approach to control for their impact. As shown in Table 3, the covariates did not have any significant impact on the fit indices. Hence, the main results for the multiple indicator LGM will be presented without these covariates.

Finally, a few words about the interpretation of the LGM results in the next section. In the multiple indicator LGM, the effect of the mean slope should be interpreted as the mean 'raw' value increase (or decrease) between the different waves. If the intercept variance is significant, it means that there is a significant difference between the individual's starting point. A non-significant intercept variance means that the students did not vary in their initial value. A significant slope variance simply means that the students differ in their slope trajectories. When both the intercept and slope variances are significant, the covariance between them becomes of interest. Given that both the intercept and slope variances are significant, a negative and significant covariance, for example, shows that students who start low have a steeper trajectory for the slope. A negative and significant covariance would then indicate that students who start low have a steeper trajectory than students starting high (Coertjens et al. 2017).

Results

Below we present our results in accordance with our research questions. First we zoom in on the results for the students' development of experience of ESD in terms of holism and pluralism, followed by the results of their development of self-perceived action competence for sustainability. The presentation of the results for the two first research questions is structured in the same way. The results for the LGM of the respective construct and the representation of the slopes are followed by the results of the cross-sectional comparison between the experimental group and the control group. Finally, the result of the third research question, the effect of ESD (in terms of holism and pluralism) on students' knowledge of action possibilities, confidence in

Table 3. Fit indices for the longitudinal growth modeling (LGM).

LGM	CFI	TLI	RMSEA
KAP			
Step 4	.993	.991	.043
Step 5	.980	.977	.045
COI			
Step 4	.991	.990	.043
Step 5	.989	.987	.040
WTA			
Step 4	.985	.983	.062
Step 5	.986	.984	.054
Holism & Pluralism			
Step 4	.950	.942	.054
Step 5	.954	.946	.048

Note: KAP = knowledge of action possibilities, COI = confidence in one's own influence and WTA = willingness to act. Step 4: Multiple indicator longitudinal growth models. Step 5: Multiple indicator longitudinal growth models including covariates (gender and type of program).

one's own influence, and willingness to act will be presented. For interested readers, the descriptive statistics (mean values and standard deviations) and reliability measures for the scales are presented separately in Appendix A.

The development of students' experience of ESD teaching

The LGM was used to determine the development of the slope factor (the students' trajectories) for the respective construct in the investigation. The main results of the LGM are shown in Table 4 below and a representation of the trajectories for the two ESD subconstructs of holism and pluralism can be seen in Figure 3. The result shows that there is a significant increase over time for holism ($p < 0.05$), but not for pluralism. This indicates that the students have experienced a development of the sustainability content in the teaching, but not a development of the pluralistic approach to the sustainability content in the teaching. The significant intercept variances ($p < 0.001$) indicate that students differ significantly from each other in their starting value, and the significant slope variances ($p < 0.01$) indicate that students differ in their trajectory. Hence, the significant intercept and slope covariances ($p < 0.001$) become important. The negative covariance indicates that the students starting low in their experience of holism and pluralism have steeper trajectories than students starting high with regard to these two components.

Including the covariates of educational track and gender did not substantially improve the model (fit indices were almost the same as for the model without the covariates, see step 4 and 5 in Table 3). Moreover, our analysis showed that girls/boys and science/technology students do not differ significantly from each other in their results. Girls differ significantly from boys only in terms of intercept (starting value) in pluralism (girls starting higher) β = .156, $p < 0.05$.

Cross-sectional control group comparison

In Table 5, the results for the cross-sectional comparison between the control group and the third wave students, regarding holism and pluralism are shown. There is a moderate effect size

Table 4. Results (β) of the longitudinal growth models for holism and pluralism.

	Mean intercept	Mean slope	Intercept variance	Slope variance	Intercept and slope covariance
Holism	0	.219 (.094)*	.409 (.055)***	.066 (.021)**	−.145 (.032)***
Pluralism	0	.143 (.083)	.388 (.051)***	.073 (.021)**	−.132 (.031)***

Note: Numbers in parenthesis are standard errors (S.E.). *** indicates $p < 0.001$, **$p < 0.01$, and * $p < 0.05$.

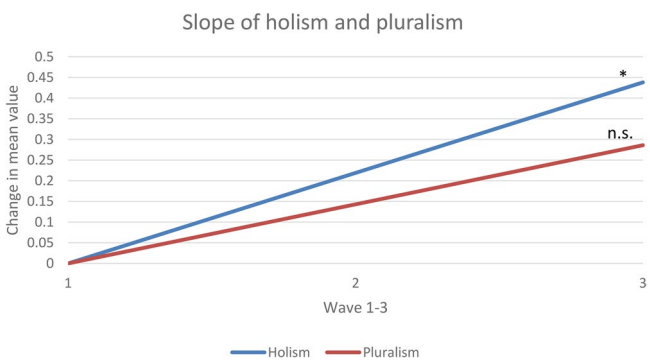

Figure 3. Slopes of the two ESD components holism and pluralism. * indicates $p < 0.05$ and n.s. is not significant.

(Cohen's $d = 0.39$) of the difference between the 12th grade students in wave 3 and the students in the control group, which implies that the development of students' experience of holism is not the result of a natural age-related development among the students, but rather of their teaching experiences. There is, however, no significant effect of the difference between the two groups regarding their experience of pluralism. Accordingly, this means that the students have not experienced more pluralism through the three waves (at least not in such a way that we were able to detect it using the current instrument and study design).

Students' development of their self-perceived action competence

As with the students' ESD experiences, LGM was used to determine the development of the slope factor (the students' trajectories) for the constructs of knowledge of action possibilities, confidence in one's own influence, and willingness to act. The main results of the LGM are shown in Table 6, and a representation of the trajectories for the three constructs of SPACS can be seen in Figure 4. The results show that there is a significant increase over time for the students' knowledge of action possibilities and willingness to act, but not for their confidence in one's own influence. The significant ($p < 0.001$) intercept variances indicate that students differ significantly from each other in their starting value. The non-significant slope variances indicate that students follow the same trajectory.

Controlling for the impact of gender and educational track (science or technology), did not substantially improve the models (fit indices almost the same as for the model without these covariates, see step 4 and 5 in Table 3). Girls and boys as well as science and technology students all follow the same trajectory. Our analysis, however, indicates that girls and science students start significantly higher than boys and technology students respectively. This is shown by the effect of gender (girls) on the intercept for knowledge of action possibilities, $\beta = .109$, $p < 0.05$; for confidence in one's own influence, $\beta = .426$, $p < 0.001$; and for willingness to act, $\beta = .493$, $p < 0.001$. Accordingly, the results of the effect of science students on the intercept are for knowledge of action possibilities, $\beta = .172$, $p < 0.01$; for confidence in one's own influence, $\beta = .444$, $p < 0.001$; and for willingness to act, $\beta = .515$, $p < 0.001$.

Cross-sectional control group comparison, self-perceived action competence

Table 7 shows the results for the cross-sectional comparison are shown. The results indicate that the students' increase over time in terms of self-perceived action competence is the result

Table 5. Cross-sectional control group comparison.

	F	*p* (sig.)	Mean (1)	Sd (1)	Mean (0)	Sd (0)	Cohen's d
Holism	14.504	.001	3.34	0.85	3.01	0.86	0.39
Pluralism	1.816	.178	3.71	0.77	3.60	0.89	0.13 (n.s.)

Note: Grade 11 and 12 wave 3 is group (1), compared to grade 11 and 12 in the control group (0).

Table 6. Results (β) of the longitudinal growth models for self-perceived action competence for sustainability, holism, and pluralism.

	Mean intercept	Mean slope	Intercept variance	Slope variance	Intercept and slope covariance
KAP	0	.072 (.030)*	.115 (.010)***	.003 (.005)	−.013 (.003)***
COI	0	.037 (.041)	.397 (.113)***	.050 (.066)	.014 (.075)
WTA	0	.097 (.036)**	.440 (.048)***	0	0

Note: Numbers in parenthesis are standard errors (S.E.). KAP = knowledge of action possibilities, COI = confidence in one's own influence, WTA = willingness to act. *** indicates $p < 0.001$, **$p < 0.01$ and * $p < 0.05$.

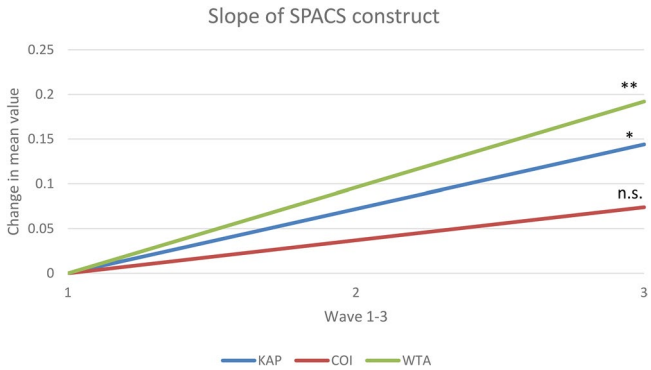

Figure 4. Slopes of the constructs of self-perceived action competence: knowledge of action possibilities (KAP), confidence in one's own influence (COI), and willingness to act (WTA). ** indicates $p < 0.01$, * $p < 0.05$, and n.s. is not significant.

of something they have experienced in the teaching, and is not entirely derived from a natural age-related development in the students. Even though our result above shows that the students' confidence in their own influence did not increase significantly through the three waves, this cross-sectional comparison shows that there is a significant difference for that construct as well. However, the magnitude of the difference in terms of effect size (Cohen's *d*) is smaller than for the other two constructs.

The effect of ESD on students' action competence for sustainability

The results of the SEM analyses used to test the effect of holism and pluralism on the three outcomes of action competence for sustainability at student level are reported in Figure 5. The fit indices showed the model to be an excellent fit for our data with RMSEA = .040, CFI = .999 and TLI = .999.The standardized regression coefficients shown in Figure 5 illustrate that the ESD dimensions of holism and pluralism have a positive effect on the action competence constructs at the student level. For holism, a medium effect is observed on the knowledge of action

Table 7. Cross-sectional control group comparison.

	F	*p* (sig.)	Mean (1)	Sd (1)	Mean (0)	Sd (0)	Cohen's *d*
KAP	6.641	.001	4.08	0.77	3.82	0.75	0.34
COI	6.536	.008	3.83	0.93	3.58	1.02	0.26
WTA	9.637	.002	3.71	1.01	3.40	1.01	0.30

Note: Grade 11 and 12 wave 3 is group (1), compared to grade 11 and 12 in the control group (0).

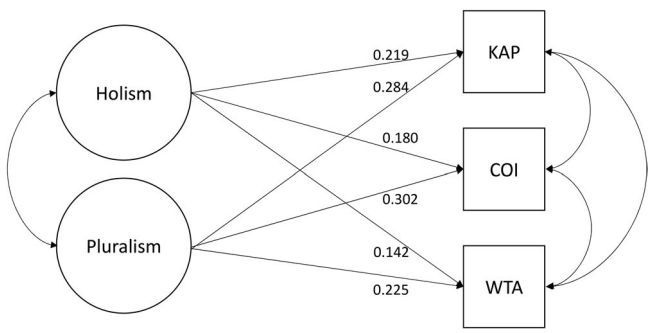

Figure 5. Effects of ESD (holism and pluralism) on the three constructs of action competence, knowledge of action possibilities (KAP), confidence in one's own influence (COI), and willingness to act (WTA).

possibilities, while small effects are observed on the other two action competence subconstructs. The medium effect of holism therefore implies that an increase of one standard deviation in holism would result in an increase of 22% of a standard deviation in knowledge of action possibilities.

Medium effects are observed for pluralism on all three subconstructs of action competence for sustainability. These medium effects represent an increase of 28%, 30%, and 23% of a standard deviation in knowledge of action possibilities, confidence in one's own influence, and willingness to act respectively, in response to an increase of one standard deviation in pluralism.

Discussion

In this study, we revisit the effectiveness of ESD. In a previous study using a cross-sectional design, we showed that ESD has effect on sustainability knowledge and self-reported behavior. In our current study, we expanded on that idea but created a longitudinal design of the development of students' experience of ESD teaching in their school and their development of action competence for sustainability. The aim was to investigate the long-term effects of ESD on students' action competence for sustainability. Our study distinguishes itself from common practice in the field of environmental and sustainability education research in two ways. First, we adopt a longitudinal design in which we follow students over the course of two school years, instead of the more common (short-term) pre- and post-tests or cross-sectional design (compare with the limitations in the field described by Chen and Liu 2020). Secondly, we take the research on the effectiveness of ESD one step further by including the concept of action competence to the investigations and do not only relate effects of ESD to cognitive, attitudinal, and behavioral outcomes (compare with Boeve-de Pauw et al. 2015). Thus in the current study, we use the contemporary notion of action competence for sustainability because that is measurable as a competence of an individual student (Sass et al. 2020), composed of three distinct subconstructs – knowledge of action possibilities, confidence in one's own influence, and willingness to act (Olsson et al. 2020).

In summary, the results of this study indicate that it is possible to, over time, develop students' experience of ESD teaching components as well as their action competence for sustainability when teachers at their school explicitly focus on developing their ESD teaching. Our result also shows that the experience of ESD among students is important for the increase of their action competence for sustainability. Below we will elaborate further on the results and methods of this study and summarize our conclusions.

Growth in students' experience of ESD and in action competence

The results of our latent growth model (LGM) analyses of the three-wave measurement show that the development of action competence among students is accompanied by the development of the perception of ESD teaching at their school. The slopes shown in Figures 3 and 4 indicate that the students' experience of holism and their knowledge of action possibilities as well as their willingness to act increased significantly over the two years that their teachers were involved in the municipal professional development course on ESD. This increased action competence in the students can, based on the results of these analyses, be interpreted in two ways. First, they could point towards an effect of the teachers' efforts to implement ESD within the framework of their professional development program. Alternatively, the increased action competence we observed in the students could merely be a result of the students aging. To discern between these two possible explanations, we included a comparison with a control group (see the study design in Figure 1). Results from this specific analysis show that when we compare students in grades 11 and 12, where the teacher had been involved in the

professional development course for two years, self-reported action competence is higher than for the students in the same grades two years earlier, when their teachers were not yet involved in the teacher professional development course. This underscores that the development in students' action competence we show in Figure 4 is not a result of the students getting older, but rather connected to the ESD implementation of their teachers. Worth noting is that even though the students' increase of confidence in their own influence is not significant in the LGM analysis, there is a significant difference in the comparison with the control group. Possible explanations for this significant difference could for example be that the students to some extent experienced ESD teaching at their school during the project, or that the control group could have different characteristics (that we could not control for) than the students in the longitudinal group.

Since the *action* part, including action training, is central to the action competence concept (Jensen 2002; Jensen and Schnack 1997; Kollmuss and Agyeman 2002; Sass et al. 2020; Short 2009) it is particularly gratifying to see that the willingness to act is possible to develop in young people through their teachers' teaching approaches. In our study we investigated the general intention to act. Other researchers argue that investigations of specific actions could contribute further and important information on the willingness to act (e.g. Malandrakis, Boyes, and Stanisstreet 2011). We therefore think that future research should consider this option. In a previous ESD effectiveness study, the relation between students' experience of pluralism in teaching and self-reported pro-sustainable behavior has been established (Boeve-de Pauw et al. 2015). It is therefore an unexpected result that the students' experience of pluralism has not developed to the same degree as their willingness to act. This may be because the willingness to act simply is something else than self-reported behavior, since an action differs from a behavior in that it is voluntary, targeted, and intended (Jensen 2000; Sass et al. 2020; 2021), whereas a behavior can be performed without motivation or with external motivation (Sass et al. 2018).

The students developed their knowledge of action possibilities during the time this study took place, which implies that they have been presented to, or studied, different action possibilities and perspectives when dealing with sustainability issues through teaching. This result is in line with the expectation for students to show increased knowledge related to sustainability and possibilities to act when they are exposed to such content in their teaching (Ardoin et al. 2018). This result is also in line with the results of several studies which have shown that when teachers explicitly address environmental and sustainability content in their teaching, the students also developed their knowledge about these issues (Ardoin et al. 2018; Boeve-de Pauw et al. 2015; Negev et al. 2008; Sass et al. 2021). Furthermore, our results also show that the students in our study experience holism to a higher degree at the end of wave three, implying that their teachers have put holism into practice more frequently as a result of their participation in the municipal teacher professional development program. To transform the current teaching tradition in a school towards pluralism seems to be a difficult task for teachers, since they are shown to encounter barriers in reorienting the teaching towards pluralistic ESD (Sund 2016; Borg et al. 2012, 2014). The limited experience of pluralism among students within the time frame of this study could confirm the existence of such barriers, or that the development of pluralism in teaching simply needs more time to be recognized among the students as experiences of the teaching. The result also confirms findings from previous studies that it is easier to develop the holistic part of the teaching than the pluralistic part, which include aspects such as critical reflection and student participation (Boeve-de Pauw et al. 2015). A look at the descriptive statistics (Appendix A and item three in the holism scale) also confirms that the students have repeatedly been exposed to the interconnection of environmental, economic, and social perspectives in the teaching, which previous studies have identified as a crucial aspect of ESD (Berglund and Gericke 2016; Sass et al. 2021).

The fact that the students did not significantly develop their confidence in their own influence in this study may reflect their experience of and level of participation in decisions and

actions at their school. In our results, the students' experience of pluralism in the teaching did not increase significantly during the time of the study. According to the ESD research literature, it is not enough for the students to be exposed to sustainability content in teaching (Boeve-de Pauw et al. 2015). They need to be trained in taking part in authentic sustainability actions (Jensen 2002; Kollmuss and Agyeman 2002; Short 2009; Sinakou et al. 2019). Furthermore, at the very core of the pluralistic approach in teaching lies the participation of students in their own learning process (Östman, Van Poeck, and Öhman 2019). Students are considered to be active participants when they are given the opportunity to share power and responsibility for decision-making and are involved in decision-making processes (Hart 2008; Shier 2001; Sass et al. 2021). Moreover, such participation gives students the opportunity to practice sustainable actions and to develop hope for the future (Ojala 2016; Stoknes 2014). One plausible reason for the students' lack of increase in confidence in one's own influence could therefore be that they have not experienced participation to any great extent at their school, even though they have could been trained in different actions in relation to sustainability. The longitudinal results of pluralism in our study strengthen this conclusion. The final item of the pluralistic scale was not included in the statistical analysis (see Appendix A, item four in the pluralism scale). However, the item concerning student participation and the descriptive statistics in Appendix A confirms that the students do not experience participation in the teaching to a high degree. For students to be able to increase their confidence in the effect of their actions (and for that matter, create hope for the future), they need to experience action-oriented ESD and contribute solutions to authentic and local sustainability issues through the teaching at their school (Ojala 2016; Östman, Van Poeck, and Öhman 2019; Sinakou et al. 2019). Moreover, the willingness of students to act in sustainability issues would be further bolstered by strengthened self-efficacy and confidence that their actions matter (Malandrakis, Boyes, and Stanisstreet 2011).

In a final remark regarding the LGM results for students' experience of holism and pluralism, we can also conclude that the students starting low (mainly boys) have steeper trajectories than the students starting high (mainly girls). Since the boys' steeper increase of their experience of ESD teaching does not seem to have more impact on their action competence than the girls', one plausible reason could simply be that boys were not likely to reflect on such experiences at the beginning of our study. This conclusion could be verified by the reasoning behind the general development of boys and girls through adolescence (Kaplan and Kaplan 2009; Kimmel 2010; Olsson and Gericke 2017).

The effect of ESD on students' action competence for sustainability

A main conclusion of the results from our structural equation model is that ESD works (see Figure 5), in the sense that a holistic approach to content as well as a pluralistic approach to teaching have positive effects on students' action competence. This confirms and further strengthens the results of Boeve-de Pauw et al. (2015). In our case, we contribute new findings in relation to action competence, which means that ESD as a teaching approach composed by holism and pluralism induces action competence for sustainability among the students.

The results from our structural equation model thus show that when teachers integrate holism in their teaching – meaning the environmental, social, and economic dimensions of sustainability issues – as well as focus on their past, present, and future, and on their local, regional, and global nature, students gain an improved self-perceived action competence for sustainability. Like the study of Boeve-de Pauw et al. (2015) shows, the cognitive part (in our case, the knowledge of action possibilities) is where holism has the biggest impact. Perhaps even more interesting is that when teachers invest more into teaching in terms of pluralism, allowing students to experience different viewpoints and opinions and letting students critically reflect on what they are learning, the students report a higher level (medium effect) of action competence for sustainability in terms of knowledge of action possibilities, confidence in one's own influence, and willingness to act.

Pluralism seems especially important for students' confidence in their own influence, i.e. that their actions matter for sustainability. Öhman and Öhman (2013) point out that participatory approaches do not necessarily lead to more diverse knowledge among students. Teachers therefore need to pay attention in the teaching process and actively challenge the students to develop diverse perspectives. Our results point to the important link between the experience of a pluralistic, participatory approach and the more cognitive part of self-perceived action competence for sustainability. Unlike the study of Boeve-de Pauw et al. (2015), we can conclude that if students experience a pluralistic approach in the teaching, it also affects the more cognitive parts of the learning outcome, in our case knowledge of action possibilities.

These results might seem straightforward, but so far, no empirical studies have been able to demonstrate the direct effects of ESD on components of action competence for sustainability. The results are especially important for the teaching practice, since we know from research that it is difficult for teachers to transform the current teaching tradition at their schools towards pluralism (e.g. Sund 2016). Our student results in this study actually confirm this, since the students did not experience significantly improved teaching at their school in terms of pluralism during the time for this longitudinal research (see Figure 3 in the Result section). Hence, it is important to support teachers in the transformation of their teaching towards ESD, so that students in the long term can develop their competences to contribute to sustainable development.

Methodological considerations and limitations

The longitudinal approach of this study discerns itself from the bulk of studies in the ESD research field, particularly in relation to the research that focuses on action competence for sustainability among young people (Ardoin et al. 2018; Chen and Liu 2020). Although longitudinal studies are important, they are often fraught with their typical difficulties. In a perfect world almost all respondents in our study would have participated in all three waves. However, collecting data from the same people repeatedly over several years can be difficult and often results in missing data when people are absent from one or more data collections (Coertjens et al. 2017). This was the case for our study, which resulted in missing data (see Table 1). There are, however, common statistical techniques for dealing with missing data in longitudinal research (Coertjens et al. 2017; Muthén and Muthén 2017). As described in the Method section, the default of the statistical software Mplus is to estimate the models under missing data theory using all available data (Muthén and Muthén 2017, 8).

When exploring our data, we looked for explanations beyond a linear increase, that could explain our longitudinal results (for example quadratic increase, systematic dropout and the tendency of students to report more extremely over the course of the study). However, we could not find any other plausible explanation for our results in the data.

Our data is based on self-reported measures, which are sometimes criticized because of the slight tendency of respondents towards over-reporting, which could mean that for example self-reported behavior does not necessarily align with actual behavior (Kormos and Gifford 2014). However, Kormos and Gifford (2014) argue that self-reported measures are an important part of environmental and sustainability education research where data collections of actual behaviors are often associated with difficulties. The issue of self-reporting therefore highlights the crucial need for strong validity of self-reported scales (Kormos and Gifford 2014), which is why we in this study use scales that have previously been developed and tested with strong validity. Moreover, another important argument is that self-reported intentions to act in a certain way have been shown to be the strongest mediator for real pro-environmental and sustainability actions (Bamberg and Möser 2007).

Another issue, which must be considered in all longitudinal studies, is that the respondents' answers could be influenced by changes of societal discourse that take place over time, so called zeitgeist effects (e.g. Puohiniemi and Verkasalo 2020). For example, the recent increase

in public attention on the issue of climate change could possibly influence the respondents' answers over time. We cannot totally exclude this possibility. However, we do not find it particularly likely that two years would be enough time to capture such zeitgeist effects among the students in this study, see Puohiniemi and Verkasalo (2020). The most plausible explanation for our results is therefore connected to the ESD development within the school, as evidenced by the students' reporting on their experiences of the teaching.

Moreover and as previously discussed, we included a control group of students (from the same school) to be able to illuminate that the development of students' action competence and the experience of their teaching was not due to the fact that students are getting older over the course of the study. However, we could not control for the two groups being totally identical, so it is possible that the control group by chance has been less interested in sustainability issues than the experimental group. If so, that may have influenced the results. Still, the control group and experimental group came from the same school and the students were similar in every respect. Therefore, the most plausible explanation for our results is that the ESD teaching is behind the differences in the results.

In the current study, we used the ESD scale consisting of holism and pluralism constructs introduced by Boeve-de Pauw et al. (2015) to investigate the students' experience of ESD when their teachers implement an action-oriented ESD (Sinakou et al. 2019) at their school. Future research on students' experience of ESD could therefore consider including action-orientation as a third component to holism and pluralism in the ESD-scale.

Another issue related to our methods is that one item in the pluralism scale had to be deleted from further analysis. The item deals with student participation (see Appendix A), and from a pluralistic perspective, an important component of pluralism is therefore missing in our analysis. Given our results discussion above, future research could elaborate further on the relation between student participation and their development of action competence. Further research could also focus on designing and investigating long-term interventions in close collaboration with teachers to support the transformation of their teaching to influence and strengthen students' action competence for sustainability.

Conclusion

Action competence for sustainability is an important outcome of ESD. The results of this study support the argument that ESD as a teaching approach is effective for the development of action competence for sustainability among students. Moreover, this study also shows that teacher professional development initiatives can develop ESD teaching over time, at least the holistic dimension, and thereby promote student development of action competence for sustainability. Given the sample of participants for this study, the results are not directly transferable to all students at all schools, but show that the efforts of teachers at a regular school participating in a long-term ESD teacher professional development program can have an impact at the student level. Based on our results we cannot claim long-term effects at the student level, but we can conclude that there are effects on students' action competence for sustainability and on their experience of ESD teaching after the two years of ESD implementation at their school. However, developing a teaching approach where students experience pluralism still seems to be a difficult task for teachers (compare with Boeve-de Pauw et al. 2015) and for designers of the teacher development program. The two years of investigations at the student level highlight the importance of duration in the ESD implementation process. We can therefore conclude that change in students' self-perceived action competence for sustainability takes time and the contribution of longitudinal research in the field of ESD research is, though difficult, important and valuable in terms of further increasing our scholarly and in-practice understanding of how to successfully support teachers in implementing ESD in their teaching. This study therefore responds to calls such as those by Ardoin et al. (2018) and by Chen and Liu (2020)

that ESD researchers need to look beyond the immediate impact of an intervention and consider the long-term effect of instruction to meet the goals of ESD.

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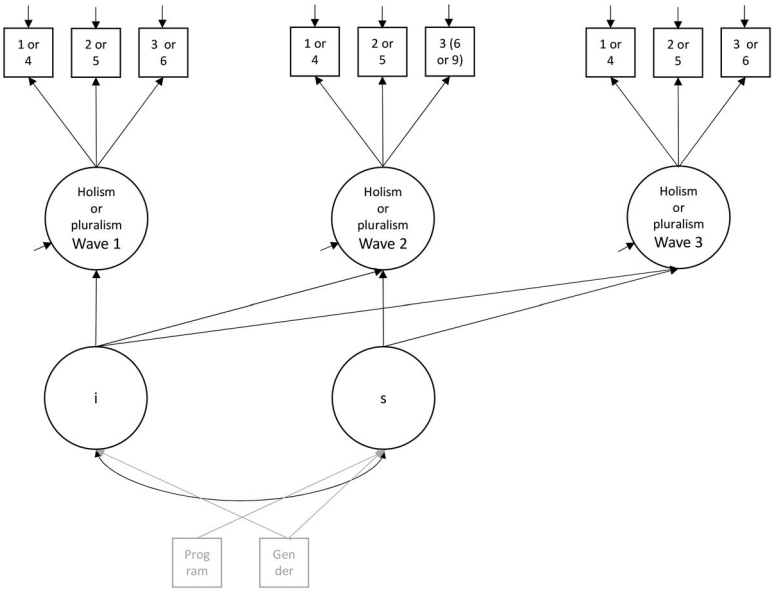
Appendix A

Items, descriptive statistics (mean values and standard deviations) and factor loadings (error variances in brackets).

	SPACS-scale	Wave 1	Wave 2	Wave 3
	Knowledge of action possibilities (α = 0.80)	**3.92 ± 0.74**	**3.97 ± 0.70**	**4.08 ± 0.76**
1	I can see different points of view on issues when people think differently.	4.11 ± 0.92 .500 (.049)	4.23 ± 0.86 .455 (.002)	4.37 ± 0.80 .607 (.047)
2	I know how to take action at school in order to contribute to sustainable development.	3.61 ± 1.11 .826 (.003)	3.68 ± 0.99 .778 (.002)	3.86 ± 1.08 .722 (.002)
3	I know how to take action at home in order to contribute to sustainable development.	4.10 ± 0.86 .812 (.013)	4.15 ± 0.83 .842 (.017)	4.14 ± 0.88 1.052 (.022)
4	I know how to take action together with others in order to contribute to sustainable societal development.	3.84 ± 0.95 .826 (.005)	3.83 ± 0.94 .851 (.003)	3.93 ± 1.01 .812 (.021)
	Confidence in one's own influence (α = 0.86)	**3.75 ± 0.94**	**3.74 ± 0.98**	**3.82 ± 0.93**
5	I believe I can influence global sustainable development	3.70 ± 1.19 .875 (.015)	3.61 ± 1.26 .914 (.013)	3.74 ± 1.20 .876 (.017)
6	I believe I can influence sustainable development in my community.	3.66 ± 1.13 .865 (.016)	3.71 ± 1.11 .898 (.013)	3.81 ± 1.09 .845 (.018)
7	I believe I have good opportunities to participate in influencing our shared future.	3.50 ± 1.17 .776 (.021)	3.50 ± 1.16 .850 (.015)	3.57 ± 1.17 .809 (.021)
8	I believe what each person does matters for sustainable development.	4.15 ± 1.03 .768 (.027)	4.15 ± 1.02 .777 (.022)	4.17 ± 1.01 .770 (.029)
	Willingness to act (α = 0.87)	**3.59 ± 0.97**	**3.65 ± 0.91**	**3.70 ± 1.01**
9	I want to take action for sustainable development in my community.	3.66 ± 1.12 .883 (.013)	3.77 ± 1.02 .865 (.015)	3.73 ± 1.11 .918 (.010)
10	I want to take action for global sustainable development.	3.84 ± 1.10 .867 (.014)	3.90 ± 1.03 .933 (.014)	3.89 ± 1.09 .906 (.013)
11	I want to engage in changing society towards sustainable development.	3.43 ± 1.17 .799 (.019)	3.45 ± 1.12 .834 (.017)	3.60 ± 1.14 .886 (.014)
12	I want schoolwork to be about how we can shape a sustainable future together.	3.46 ± 1.26 .741 (.023)	3.50 ± 1.16 .726 (.024)	3.58 ± 1.27 .809 (.021)
ESD-scale				
	Holism - approach to content (α = 0.79)	**3.20 ± 0.90**	**3.26 ± 0.87**	**3.33 ± 0.85**
1	In school, we look at the connections between the past, the present, and the future as regards various issues	3.46 ± 1.06 .796 (.024)	3.46 ± 0.96 .788 (.024)	3.49 ± 0.98 .837 (.023)
2	In school, we look at both local and global problems and the connection between them	3.26 ± 1.07 .784 (.022)	3.29 ± 1.01 .860 (.020)	3.32 ± 1.00 .849 (.022)
3	In school, we look at how economics, social issues, and environmental problems are connected	2.92 ± 1.06 .780 (.022)	3.06 ± 1.06 .778 (.024)	3.20 ± 1.01 .751 (.027)
	Pluralism - approach to teaching (α = 0.68)	**3.70 ± 0.79**	**3.78 ± 0.77**	**3.71 ± 0.77**
4	When we have class discussions, it is possible for many different views to emerge	3.76 ± 1.00 .696 (.027)	3.76 ± 0.93 .721 (.033)	3.72 ± 0.96 .645 (.035)
5	When we read texts in school, we usually take a critical look at the content	3.70 ± 0.96 .685 (.027)	3.83 ± 0.95 .628 (.035)	3.71 ± 0.99 .648 (.033)
6	In school, we are encouraged to take a stand and have our own opinions on the issues at hand	3.64 ± 1.06 .681 (.023)	3.74 ± 0.99 .800 (.029)	3.68 ± 0.99 .804 (.028)
7	We decide what we study ourselves, with support of the teacher	2.55 ± 1.03	2.59 ± 1.02	2.61 ± 0.93

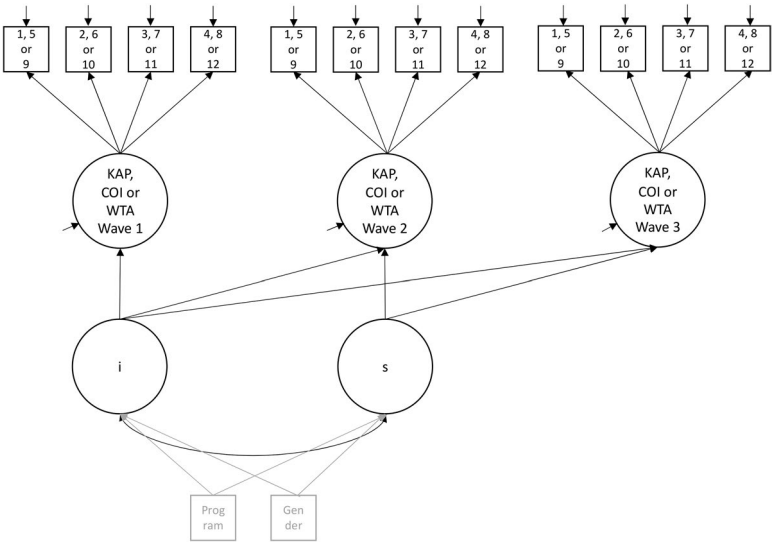
Note: Item 4 in the pluralism scale was deleted from the analysis and therefore marked in grey. All factor loadings are significant at the $p<.001$ level.

Appendix B



Longitudinal Growth Model for the self-perceived action competence for sustainability constructs. Covariates, science program and gender, were only included in the fifth step of the analysis and are therefore marked in gray.

Appendix C



Longitudinal Growth Model for the ESE components of holism and pluralism. Covariates, science program and gender, were only included in the fifth step of the analysis and are therefore marked in gray.