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# Development of Students' Sustainability Competencies: Do Teachers Make a Difference?

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**Abstract:** Sustainability competence is an important goal of Education for Sustainable Development (ESD) in school. It is therefore anchored in the education plans of almost all school tracks in Germany. However, empirical findings regarding ESD in schools are scarce. The present study thus examined how sustainability competencies of secondary-school students develop within the course of a school year. Based on a proposed framework model of sustainability competencies, we assessed (a) students' sustainability-related knowledge, (b) their affective-motivational beliefs and attitudes towards sustainability, as well as (c) their self-reported sustainability-related behavioral intentions. Our sample comprised $n$ = 1318 students in 79 classrooms at different secondary school tracks (Grades 5–8) in Baden-Wuerttemberg (Germany). Measurements were taken at the beginning and at the end of the school year after the introduction of ESD as a guiding perspective for the new education plan. We observed an increase in students' sustainability-related knowledge but a decline in their affective-motivational beliefs and attitudes towards sustainability over the course of one school year. Multilevel analyses showed that, at the individual level, prior learning requirements as well as ESD-related characteristics (students' activities and general knowledge of sustainability) proved to be the strongest predictors of their development. In addition, grade- and track-specific differences were observed. At the classroom level, teachers' attitudes towards ESD as well as their professional knowledge were found to be significant predictors of students' development. The higher the commonly shared value of ESD at school and the higher teachers' self-efficacy towards ESD, the higher was the students' development of sustainability-related knowledge and self-reported sustainability-related behavioral intentions, respectively. The significance of the findings for ESD in schools is discussed.

**Keywords:** Education for Sustainable Development (ESD); competence development; environmental education and sustainability-related skills; knowledge; attitudes; multilevel analysis



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## 1. Introduction

In view of the worsening global problems and crises, the (abstract) idea of sustainable development is currently experiencing new "tailwind" and broad acceptance in society. Already some decades before, global environmental problems led to numerous attempts to establish principles of sustainability. In particular, pioneering events could be observed from the early 1970s onward. The United Nations Conference on the Human Environment in Stockholm (1972) [1] as well as the Brundtland Commission and its resulting reports (1987) included the first attempts at a modern definition of sustainable development. Despite the numerous approaches that exist today to define sustainability and sustainable development, the Brundtland Report's definitional formulation, "Our Common Future", can be cited as one of the most universal and usable. It describes sustainable development as a development that "meets the needs of the present without compromising

the ability of future generations to meet their own needs" [2], p. 24. Put more simply, we should live at present in such a way that future generations can also live well, which means, among other things, in an intact environment, in peace and justice, provided with all the necessities of life (food, water, etc.) and with the opportunity to pursue meaningful work.

However, to what extent is it possible to translate the idea of sustainable development "from paper" into practice? Educational institutions and the educational program of ESD at schools and universities hereby play a decisive role (for the potential of higher education institutions as platforms to disseminate the Sustainable Development Goals (SDGs) proposed by the United Nations (UN), see, e.g., [3,4]). In the past decade, research literature has increasingly emphasized the pivotal role of academia and higher education institutions at the tertiary level (e.g., [5,6]): on the one hand, universities frequently tackle region-specific issues, provide ESD to local actors, and set thematic sustainability-related priorities in research and teaching. On the other hand, they are supposed to support their students and staff beyond skill development to cope with the complex challenges of sustainability, to raise their awareness in this regard, and to set strategic goals in their sustainability implementation processes. Thus, higher education institutions are important contributors to promote sustainability-related principles [ibid.].

Our society faces a generational task in shaping sustainable development. An effectively anchored ESD equips the next generations with the appropriate skills they need to meet the challenges of the present and the transition to a sustainable society. Furthermore, with regard to the interests of intergenerational justice, intensive efforts should also be made to promote the development of sustainability competencies required for this applying of a holistic educational concept. In this context, Vare and Scott (2007) [7], p. 192, pointed out that ESD must surely be about initiating a learning process and not about "'rolling out' a set of pre-determined behaviours". They therefore proposed two complementary approaches and a distinction that has since been intensely debated in educational science: according to the first approach, ESD is about promoting informed, skilled behaviors and ways of thinking, which is useful in the short-term where the need is clearly identified and agreed. Following the second approach, ESD (as was formulated by Vare and Scott (2007) [7], p. 191) is more about building a "capacity to think critically about what experts say and to test ideas, exploring the dilemmas and contradictions inherent in sustainable living".

In 2016, new education plans were introduced in the German Federal State of Baden-Wuerttemberg, in which ESD was anchored as one of six guiding perspectives for the school curriculum. In these new education plans, the objective of ESD was expressed as follows:

> "*Education for Sustainable Development empowers learners to make informed decisions and act responsibly to protect the environment and create a functioning economy and a just global society for current and future generations*" ([8], translated by the authors).

So far, however, empirical findings are not yet available that examine the effects of this implementation on students' sustainable development competencies and the role which teachers hereby play. Thus, with the present study, we tried to close this gap: following approaches of school effectiveness research, this paper explores the question of whether teacher-related characteristics affect students' sustainability competencies, attitudes, and behaviors beyond their individual prerequisites. The aim of this paper was to contribute to a better understanding of which factors are associated with positive developments, to identify key levers to promote students' development in this regard, and to formulate some possible recommendations of how to maintain and (further) develop ESD practice in schools.

In the following, we will first provide a short overview of the theoretical and methodological background of our study: Section 2.1 gives an overview about the conceptualization of ESD and the current state of research on this topic in Germany. These considerations will be framed by an educational effectiveness perspective and relevant research findings on this topic that have been available to date (Section 2.2). Based on this, we will specify our research questions (Section 2.3) and describe the method, data, and analysis approach (Section 3). Using data from a student sample assessed in 2019, we will

then present findings of descriptive and correlational analyses regarding the development of students' sustainability competencies and their correlates (Sections 4.1–4.3). Finally, multilevel analyses (Section 4.4) will be performed in order to predict students' sustainability competencies by student and teacher characteristics. In Section 5, we will discuss the main findings with regard to our research questions and their implications for further research and practice.

## 2. Theoretical and Methodological Background of the Study

### *2.1. Conceptualization of ESD and Current State of Research*

In the school context, ESD can be understood as the totality of actions through which learners are supported in acquiring the sustainability competencies (including, in particular, knowledge, positive attitudes, and behavioral readiness) they need to shape a sustainable development (e.g., [9,10]). Such a definition of the ESD concept is deliberately formulated broadly and, therefore, also ensures adaptation to, for example, an uncertain future or societal changes. With regard to the competencies to be promoted in learners in the context of ESD, numerous recommendations have been formulated [10–14]. However, this multitude of recommendations is matched by only a very limited number of empirical operationalizations of the recommended competencies (e.g., [9,15,16]). As a result, it is difficult to prove that the recommended competencies have been successfully promoted in educational contexts [10]. However, if the effectiveness of teaching and other pedagogical interventions cannot be empirically measured, no evidence-based recommendations for the further development of ESD can be derived. It is therefore not very surprising that the number and quality of empirical studies that allow statements on the effectiveness of ESD are currently still considered as insufficient (e.g., [16–18]). Recent impact studies examined, in particular, the promotion of facets of sustainability competencies (such as systems thinking [15], knowledge about climate change [19,20], or values-thinking competency [21] within the framework of single school subjects or teaching units). However, ESD in schools is not only taught in individual subjects (e.g., biology, geography, politics) and in specific delimited units. Instead, ESD is rather the task of many subjects, and it is important to look at the effects of the interaction on learning outcomes beyond subject boundaries and for longer periods of time (for example, entire school years). However, to our knowledge, such empirical studies have not yet been conducted, and corresponding research findings are not available to date. Furthermore, it is important to focus more on the teachers, i.e., those actors who implement ESD in school, and to examine the effects they have on learners. Beyond this, the question also arises of whether teachers' professional knowledge, attitudes towards ESD, and the ways of teaching ESD have changed in the past years.

### *2.2. Considering Students' Development from an Educational Effectiveness Approach Using a Multilevel Framework*

Generally speaking, people are embedded in different social contexts throughout their lives (e.g., [22,23]). Social contexts can be defined as the respective environments (e.g., institutional or cultural environment) in which individuals are embedded and which thus inevitably and continuously shape their development [24,25]. In childhood and adolescence, schools and school classes emerge as educational contexts within institutions that not only set the course for lifelong learning, but also structure young adults' opportunities for transitions into other social contexts, such as employment (e.g., [26]). Beyond this, schools can be considered as a central place of socialization as children and adolescents spend more time in educational contexts than in any other extrafamilial context [27]. Consequently, institutional contexts can influence students' learning and their attitudes and behavior, and thus, they face the task to provide students with developmentally appropriate opportunities to fulfill their basic human needs, such as experiencing competence [ibid.].

In order to understand and empirically investigate the importance of school contexts, theoretical approaches from international research on school quality and school effectiveness research are of particular interest (e.g., [28–30]). Common features of these models

include the consideration of a multilevel structure, in which contextual conditions and process indicators of school quality are located at multiple levels: drawing on the socioecological approach to human development by Bronfenbrenner [31], individuals are integrated into multiple environments or interaction systems. Such developmental ecologies are concentric and might be rather proximal or rather distal to the individuals. The exposition to such different environments also provides individuals with different experiences and might promote or constrain individual developmental opportunities. In this sense, school classes, for example, can also be understood as designed environments compared to the rather natural and proximal environment of interactions between children and their parents [32]. However, even the effects of macrosystem characteristics flow through the proximal levels of the ecological systems and also shape individuals' development [ibid.]. Thus, in the sense of Bronfenbrenner, it could be assumed that the macrosystem of the environment which individuals are embedded in and in which they participate influence individuals' development within the microsystem.

More specifically, and with regard to education, learners are embedded into different contexts, which are hierarchically nested within and mutually related to each other. This means that they have multidirectional, i.e., reciprocal, relationships to each other, in each of which they find specific conditions for their development, e.g., with regard to learning [33]: at the center are individual learning and teaching processes as well as interactions between students and their teachers, which form the intersection between the conditions of educational processes at the teacher and student level. For example, students learn together with their peers within classrooms within schools. Schools, in turn, are subject to structural regulations at the municipal or regional level, which, as a whole, represent the educational system.

In line with such models, the school class can be understood as the proximal context, as it represents the immediate and commonly shared environment for students' learning and development in the school context [27,32]. In addition, the particular class context may be shaped due to assignment processes within single schools [34], which may cause classes to differ in the composition of the student body and their students' specific learning requirements. Similarly, according to Ditton [29], instructional or classroom characteristics are related to the specific teaching–learning situation and should thus be addressed by measures of quality control and quality assurance to improve quality in education. Furthermore, considering classrooms as educational contexts takes into account the fact that even school classes as single units within the same school may differ in their respective composition of the student body: individual school classes therefore do not necessarily adequately represent the school composition, but they may rather differ, for example, in the quality of instruction and the way in which they facilitate students' learning and development processes [35,36].

### *2.3. Research Questions and Hypotheses*

Based on these theoretical considerations regarding the conceptualization of ESD, the importance of characteristics of the school learning environment outlined above and the so far existing empirical findings, the question about the significance of teacher and teaching characteristics which might foster students' development of sustainability competencies can be raised. The present study thus brings together these two strands of research on students' learning development and teacher characteristics that are relevant in this regard. Our study aims at answering the following research questions (RQ):

1. Do students' (a) sustainability-related knowledge, (b) their sustainability-related attitudes, and (c) their sustainability-related behavior develop within one school year?
2. Are teacher characteristics related to the development of students' (a) sustainability-related knowledge, (b) their sustainability-related attitudes, and (c) their sustainability-related behavior over the course of one school year?

Thus, the aim of our study was, first, to identify individual student characteristics as well as those characteristics of the learning environment that are associated with differential

developmental trajectories. Second, we examined the role of the teachers and analyzed whether their attitudes and knowledge as indicators of their professional competence [37] hereby make a difference. Third, we assessed these effects for the different aspects of sustainability competencies.

With regard to the findings of previous studies, we expected positive developments of students' sustainability competencies within the course of a school year (H1 relating to RQ 1). For teacher characteristics, we expected that positive attitudes and a higher professional knowledge would be associated with positive developments of students' sustainability competencies (H2 relating to RQ 2). Finally, as our questionnaire captured three different dimensions of sustainability competencies that are empirically separable [38], we expected the considered predictors to be differentially predictive of students' knowledge, their affective-motivational beliefs and attitudes, as well as their behavioral intentions regarding sustainability (H3 relating to RQ 2).

## 3. Method

### *3.1. Sample*

The database of our study was a stratified sample of 10 secondary schools of different school tracks in Baden-Wuerttemberg (Germany). The selection of schools included in our sample represented the state-wide track distribution. Schools were randomly selected from a list of all state-approved secondary schools. In case that schools declined to participate in our study, succeeding substitute schools were also drawn randomly. The distribution of schools among the different tracks was based on the transition rates to general education schools at the secondary level: our sample comprised one basic-track school (Werkrealschule), two intermediate-track schools (Realschule), four academic-track schools (Gymnasium), and three comprehensive-track schools (Gemeinschaftsschule). Regarding the distribution of school tracks, our sample can be considered as approximately representative of all secondary schools in Baden-Wuerttemberg [39].

Data was collected at the beginning and end of the school year of 2018/2019. This procedure allowed us to identify potential changes in the three dimensions of sustainability competencies in the course of one school year. Overall, 1622 students aged 9–16 (average age = 11.73, SD = 1.26) participated in the first measurement at the beginning of the school year. As participation in our study was voluntary, questionnaires from 1588 students were also available at the end of the school year. For longitudinal analyses, we considered a total of 1318 students from 79 classrooms, including eight classes at basic tracks, 16 at intermediate tracks, 22 at comprehensive tracks, and 32 at academic tracks. If available, two classes from Grade 5–8 (i.e., eight classes per school) were surveyed at each school. Excluding students without any information regarding their gender led to a base sample of $n$ = 1295. At the student level, the gender and grade levels were almost evenly distributed (Table 1). Regarding track affiliation, the majority of students attended academic tracks, followed by intermediate tracks, comprehensive tracks, and basic tracks. The average class size in the subsample selected for further analyses was M = 18.7.

At the teachers' level, $n$ = 113 teachers of the classes we investigated participated in an online survey in 2019. We were only interested in teachers teaching subjects with the most numerous ESD links according to a school curriculum analysis [9]. These subjects were related to the classical sciences, social sciences, and humanities disciplines. Their age ranged from 27–65 years (average: 41.0 years). Female teachers were the majority in our sample (61.9%). Their average teaching experience was 12.9 years. About two-thirds (67.3%) of the participating teachers taught subjects that traditionally have a close connection to ESD (e.g., biology, geography, social studies). Around one-third of the teachers taught German and history (subjects that had previously been less closely related to ESD in their subject culture, but which now have a corresponding reference in the new education plan).

**Table 1.** Description of the student sample.

| | *n* | % |
|---|---|---|
| Gender | | |
| female | 637 | 48.4 |
| male | 465 | 46.6 |
| diverse | 66 | 5.0 |
| Grade | | |
| 5 | 359 | 27.7 |
| 6 | 326 | 25.2 |
| 7 | 328 | 25.3 |
| 8 | 282 | 21.8 |
| Track | | |
| basic track (Werkrealschule) | 102 | 7.7 |
| intermediate track (Realschule) | 332 | 25.2 |
| comprehensive track (Gemeinschaftsschule) | 250 | 19.0 |
| academic track (Gymnasium) | 634 | 48.1 |

### *3.2. Measurement Instruments*

#### 3.2.1. Measurement Instruments at the Student Level

A questionnaire instrument was developed to assess different aspects of basic sustainability competencies at the lower secondary level [38]. The complete questionnaire is documented in the final report of our research project [40] (p. 50 ff.: paper-pencil student questionnaire, p. 81 ff.: online teacher questionnaire). An English translation of the student questionnaire is available from the authors upon request. This questionnaire was based on previous research from environmental and sustainability (consciousness) research (e.g., [41–44]) as well as from environmental education and ESD (e.g., [45,46]).

Regarding construct validity, scales and items were derived from our theoretical model of sustainability competencies [10] that, amongst other things, distinguished between cognitive (knowledge), affective-motivational beliefs and attitudes, and behavior-related (self-reported intentions) target dimensions of sustainability competencies. To ensure content validity of this measurement instrument, a comprehensive analysis of the curricula was carried out beforehand as part of a method-integrative approach (mixed methods). Furthermore, the content and curricular fit of the items that we used to operationalize sustainability competencies was examined by teachers and external ESD experts.

The student questionnaire [9], amongst other things, assessed

1. socio-demographic information, such as gender (1 = *female*, 2 = *male*, 3 = *no answer*), immigrant background (operationalization: German as first language or language spoken at home; 1 = *yes*, 2 = *no*, 3 = *other*), and self-reported grade point average (operationalized by the average of the last report grade in German, mathematics, and biology). The student questionnaire also assessed students' familiarity with the concept of sustainability (example item to assess students' cross-curricular sustainability knowledge: *Have you ever heard of the term "sustainability" or "sustainable"?*; 1 = *no*; 2 = *yes, but I could not explain it*; 3 = *yes, but I would have to think a little before I could explain it*; 4 = *yes, I know the term and can explain it to others*). Students were also asked whether they had ever heard of *Fridays for Future* (1 = *no*; 2 = *yes*; 3 = *yes, and I took part in it*). Further school-related characteristics related to the grade level and the attended school track (1 = *basic track*, 2 = *comprehensive track*, 3 = *intermediate track*, 4 = *academic track*).
2. sustainability-related knowledge (16 content-related knowledge question ([40], p. 53 ff.) based on the education plan analyses; for preliminary analyses and reliabilities of this scale, see Section 3.3.2). Example item:

   *If someone wants to live sustainably, they should . . .*
   *Please mark only one answer (the most applicable one).*

- ☐ . . . *always donate money for aid and conservation projects in poorer countries.*
- ☐ . . . *if possible, eat local farming products, invest money profitably, and fight for worldwide peace.*
- ☐ . . . *eat as vegan as much as possible to protect local animal species and to create a fairer life for animals and humans.*
- ☐ . . . *respect nature, advocate for justice, and make sure everyone has enough to live on.*

3. affective-motivational beliefs and attitudes towards sustainability (16 questions [40], p. 60 f.). Example item: *When I hear about cars which consume a lot of fuel and emit a lot of exhaust fumes, I get angry*.
4. self-reported sustainability-related behavioral intentions (13 questions [40], p. 64). Example item: *When I buy chocolate from my pocket money, I buy organic or fair-trade chocolate.*

Knowledge items were in single choice format. To reduce guessing probability, instead of using a true/false-format, three distractors were formulated for each knowledge item (see example above). Affective-motivational beliefs and attitudes towards sustainability as well as self-reported sustainability-related behavioral intentions were measured using a 4-point Likert-type scale, with higher values indicating a higher agreement (for an in-depth description of the measurement instruments, see [9]).

As, in the following, the focus is on the identification of summative indicators of sustainability-related knowledge, affective-motivational beliefs and attitudes towards sustainability, and behavioral intentions, the underlying theoretical models and processes of change may differ but are not the aim of the present study (for knowledge as propositional networks, see, e.g., [47]; for attitude change, see, e.g., [48]).

#### 3.2.2. Measurement Instruments at Teachers' Level

At the teachers' level, items used to assess teachers' professional knowledge regarding ESD, their practices of ESD in teaching, as well as their attitudes towards ESD largely stemmed from an earlier study based on a representative sample of teachers which had been conducted in 2007 in Baden-Wuerttemberg [49].

Data collection in 2019 was administered as an online survey (Unipark software package). The teacher questionnaire comprised 26 questions with dichotomous, Likert-scaled, and open-ended questions. The survey questions related to:

1. Sociodemographic information: school track, subjects taught in the classes participating in our study, gender (1 = *female*, 2 = *male*, 3 = *diverse)*, age and teaching experience (both in years), and teachers' attitudes towards environmental protection and sustainable development (example item: *I am worried or outraged when I think of the environmental challenges our children and grandchildren might have to face*).
2. Knowledge of ESD, ESD-related programs, and materials (example item to assess teachers' sustainability-related knowledge: *Have you ever heard of the term "sustainable development"?*; 1 = *no*; 2 = *yes, but I could not name any goals/contents*; 3 = *yes, but I would have to think a little before I could explain any goals/content*; 4 = *yes, I could spontaneously name goals/contents*).
3. ESD practices in the classroom (e.g., topics taught, number of lessons, objectives pursued in the lessons, and applied teaching methods)
4. Structural hindering and fostering factors in school, such as teachers' attitude towards ESD (example item: *ESD topics are important at our school*; 4-point Likert-type scale, with higher values indicating a higher agreement) and their assessment of the importance of ESD at their school (e.g., ranking of ESD in relation to various other cross-cutting issues currently relevant in everyday school life, such as inclusion/inclusive education, language education, digitization, and cultural education).

Both the student and the teacher questionnaire were approved by the Ministry of Education, Youth, and Sports Baden-Wuerttemberg; the Ministry of Environment, Climate Protection, and the Energy Sector Baden-Wuerttemberg; and the Foundation for Environmental Protection (Stiftung Naturschutzfonds).

### *3.3. Preliminary Analysis*

#### 3.3.1. Treatment of Missing Values

First, the extent of missing values was determined. There were no missing values for students' grade level as this was one of the tracking variables. At the first measurement, the proportion of missing values for students' gender was 1.7%. Regarding students' sustainability-related knowledge, more than 5% of the values (maximum 8.6%) were missing in only four of the 16 tasks of the test. Missing values in the knowledge tasks were treated as not solved and coded with 0 = *incorrectly*. At the second measurement, the proportion of missing values for the scales assessing students' affective-motivational beliefs and attitudes towards sustainability and their self-reported sustainability-related behavioral intentions was also below 5%.

Second, we examined whether missing values occurred at random. At the first measurement, the percentage of missing values for all items on the scale of affective-motivational beliefs and attitudes towards sustainability was less than 5%, but missing values were not completely randomly distributed (Little's MCAR test $p < 0.001$). On the scale for self-reported sustainability-related behavioral intentions, the proportion of missing values was also below 5%; the values were completely randomly distributed (MCAR test $p = 0.17$). If the proportion of missing values was either less than 5% or the values were completely randomly distributed, the missing (numerical) values were replaced with the EM algorithm in SPSS 26. At the second measurement, missing values on the scales measuring students' affective-motivational beliefs and attitudes towards sustainability and their self-reported sustainability-related behavioral intentions were not completely randomly distributed (MCAR test $p < 0.001$). Missing values were dealt with in the same way as at the first measurement.

#### 3.3.2. Quality of the Measurement Instruments

As a measure of reliability of our instruments, we calculated McDonald's Omega ($\omega$), since this measure leads to more precise estimates, even in the event of a frequent violation of the tau equivalence. The omega estimate is based on the factor loadings of a forced one-factor maximum likelihood factor analysis [50].

Table 2 displays the reliability values for the knowledge scale, the affective-motivational scale, as well as for the scale measuring students' self-reported behavioral intentions. In the knowledge scale, two items from the original scale had to be excluded due to low reliabilities, so the scale was reduced to 16 items. The other two scales were used in their original number of items. The scales showed satisfactory to good reliability values at both measurement times.

**Table 2.** Reliability of the measurement instruments.

| Scale | Number of Items | $\omega_{t1}$ | $\omega_{t2}$ |
|---|---|---|---|
| Sustainability-related knowledge | 16 | 0.69 | 0.73 |
| Affective-motivational beliefs and attitudes towards sustainability | 16 | 0.84 | 0.87 |
| Self-reported sustainability-related behavioral intentions | 13 | 0.70 | 0.74 |

### *3.4. Analysis Approach*

We applied three different kinds of analysis approaches to analyze basically two different questions about (a) the changes in students' sustainability competencies (RQ1) and (b) their contextual conditions (RQ2): First, in order to examine the extent to which students' sustainability skills develop over the course of the school year (RQ1), we conducted analyses of variance (ANOVA) with repeated measurements using the software SPSS for each of the three dimensions of sustainability competencies as dependent variables. In each case, the same students were tested on the same dependent variables at different points in time. The analyses of variance thus checked whether the mean values of several

dependent groups differed, with the groups in this case representing the two measurements. This procedure allowed us to check whether students' sustainability competencies at the beginning of the school year significantly differed from the respective values at the end of the school year. In addition, this procedure made it possible to take into account the nested data structure (students nested in school classes) at the same time.

Second, in order to examine the correlations between student and teacher characteristics on the development of students' sustainability competencies, we combined the individual level of students to the higher level of teachers. By doing so, each observed individual was clearly assigned to a single superordinate group, and it was checked whether individual-level factors were related to corresponding factors within the aggregated unit (class, teacher). Prior to more complex multivariate analyses, we examined bivariate correlations between different average indicators of students' sustainability competencies at the aggregate level and teachers' characteristics.

Third, the approach of multilevel analysis thereby allowed for a methodologically more precise analysis of hierarchically nested data. Such an approach allowed for the specifying of adequate models for data that were hierarchically arranged in several levels. Thus, a major advantage of multilevel analysis is the simultaneous estimation of predicting variables at different levels, which makes it possible, for example, to model the relationship between individual and classroom factors and to describe effects of the classroom context at a higher analysis level on individual student outcomes at a lower analysis level (for a description of multilevel analysis procedures, see, e.g., [51,52]).

In the present research project, as described, the data structure was hierarchical. Data collected at Level 1 (to operationalize students' sustainability competencies) may have been simultaneously influenced by Level 2 variables (e.g., characteristics of teachers assigned to classes, students' classroom affiliation). Statistical modeling therefore had to account for this hierarchical multilevel data structure. With regard to previous findings from school effectiveness research (see Section 2.2), it could be assumed that higher-level variables, such as classroom affiliation or the attendance of a particular school track, might have had an influence on the outcome variable(s) at Level 1, i.e., that different dimensions of sustainability-related competencies (knowledge, attitudes, behavior, etc.) might have depended on the respective institutional learning and developmental environment. In the present research project, with its data collection at both the student and the teacher level, it was possible to examine the effects of teacher characteristics at Level 2 and to investigate, for example, whether teachers who had attended ESD training courses or who had a positive attitude towards ESD enhance students' development of sustainability competencies. Otherwise, to put it more technically, it could now be investigated, for example, whether the group means of sustainability competencies of individual school classes differ from the overall mean and whether such possibly detectable differences between school classes could be systematically predicted by higher-level variables.

For the multilevel analyses, we excluded those classes in which less than 10 students had participated in our survey as well as those classes for which no teacher data were available. We also excluded those teachers to whom no student data could be assigned. This resulted in an analysis sample of $n = 1178$ students from 63 classes and $n = 113$ teachers, respectively, who taught sustainability-related subjects in these classes.

## 4. Results

### *4.1. Development of Students' Sustainability Competencies over the Course of the School Year*

In the following, we will describe students' sustainability-related knowledge, their affective-motivational beliefs and attitudes towards sustainability, as well as their self-reported sustainability-related behavioral intentions at the beginning and at the end of the school year of 2018/2019.

Analyzing RQ 1, cross-sectional analyses showed that for both measurement points at the beginning and at the end of the school year, students' sustainability-related knowledge was significantly higher with increasing grade level (Figure 1). Regarding the longitudinal

development over the course of the school year, the results of the analysis of variance with repeated measurements indicated a significant increase in students' sustainability-related knowledge in all grades ($F(1, 1261) = 29.99$, $p < 0.001$).

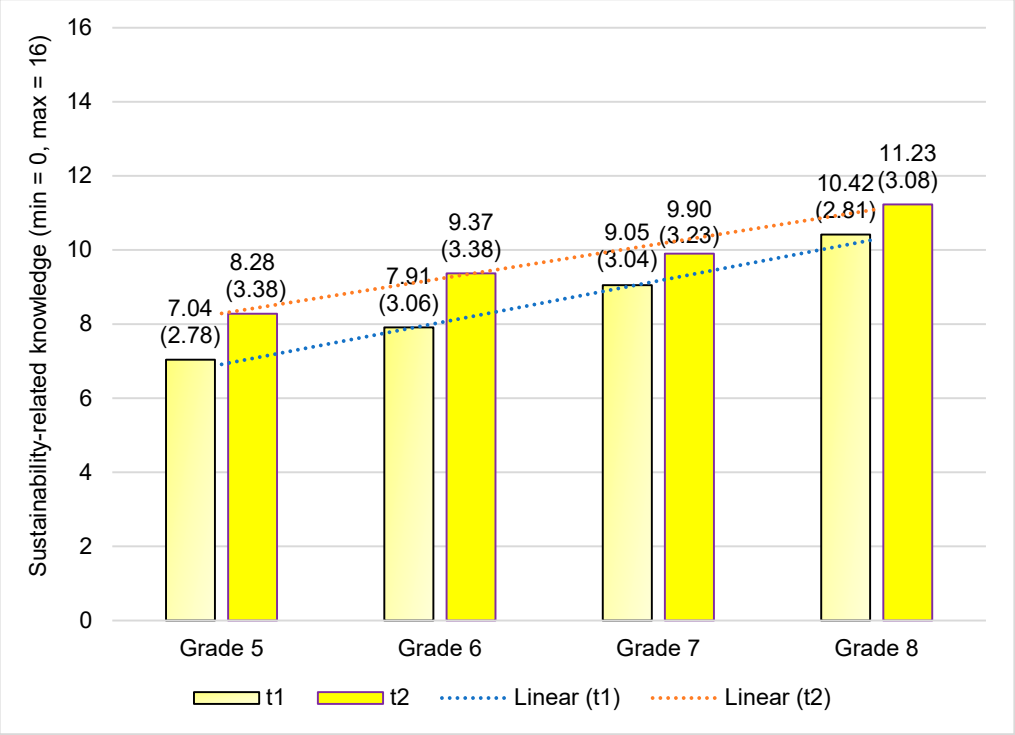


**Figure 1.** Change in Students' Sustainability-Related Knowledge by Grade Level.

In contrast to sustainability-related knowledge, however, longitudinal analyses revealed for students' affective-motivational beliefs and attitudes towards sustainability (Figure 2) a statistically significant decrease within one school year across all grade levels ($F(1, 1261) = 11.99$, $p < 0.001$). Beyond that, students showed lower values in their affective-motivational beliefs and attitudes towards sustainability with increasing grade level ($p < 0.001$): the higher the grade level, the less favorable were students' affective-motivational beliefs and attitudes towards sustainability.

Regarding students' self-reported sustainability-related behavioral intentions (Figure 3), the changes between the beginning and end of the school year were insignificant ($F(1,1261) = 0.49$, $p = 0.485$). However, we observed that the higher the grade level, the lower was students' self-reported sustainability-related behavior ($p < 0.001$).

As an interim conclusion, it could be stated as a first result that the cognitive dimension of sustainability competencies positively changed over the course of the school year. Second, the affective dimension of sustainability competencies slightly declined during a school year, whereas students' self-reported sustainability-related behavioral intentions remained rather constant. In this regard, further in-depth group comparisons need to clarify for which subgroups of students these declining trends apply. However, the observed increase in students' sustainability-related knowledge and the decline of students' affective-motivational beliefs and attitudes towards sustainability with increasing grades are well in line with previous research findings on national and international level [53–55]. The findings also raise the question of which dimensions of sustainability competencies should be focused on or should be given greater priority in instruction.

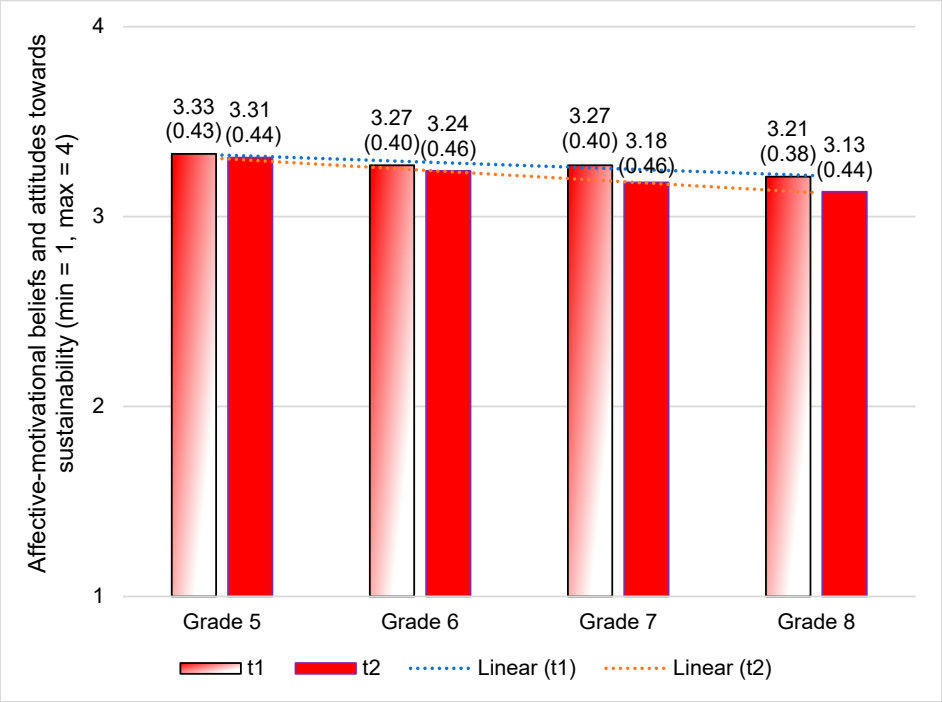


**Figure 2.** Change in Students' Affective-Motivational Beliefs and Attitudes towards Sustainability by Grade Level.

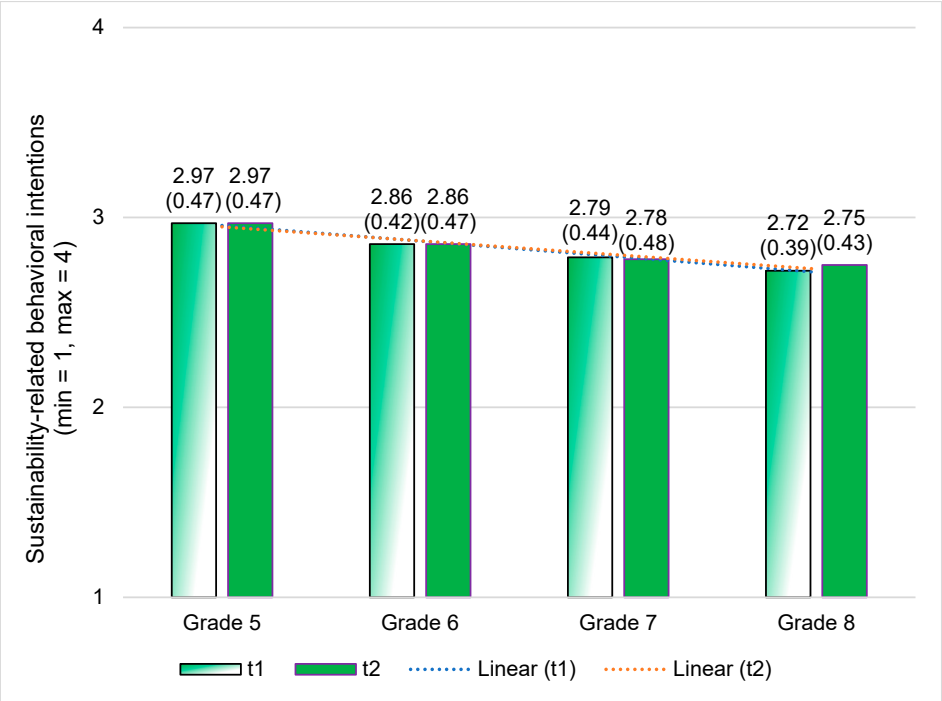


**Figure 3.** Change in Students' Self-Reported Sustainability-Related Behavioral Intentions by Grade Level.

### *4.2. Teachers' Attitudes towards and Knowledge of ESD and How ESD Is Implemented in School and Class*

In addition to the different dimensions of sustainability competencies on part of the students, our study also examined teacher characteristics and their instructional practices. Among other things, we investigated teachers' attitudes towards ESD, the importance they attached to ESD, and the extent to which they aligned their teaching with the guiding

principle of ESD in the school curriculum. In the following, some selected results of the teacher survey are presented (for further details see [56]).

Teachers were asked about their general attitudes towards environmental protection as well as towards essential features of sustainable development (10 items, Cronbach's $\alpha = 0.85$). The overall mean of their attitudes (assessed on a five-point Likert scale, in which higher values indicated stronger agreement) was very high (M = 4.28, SD = 0.52).

In line with these high expressions in attitudes towards ESD, teachers also demonstrated a high level of general knowledge in this area: approximately 98% of respondents indicated that they had heard of sustainable development. Most could even name the goals and content of sustainable development spontaneously (65.5%) or after a bit of reflection (27.4%).

In our questionnaire, teachers were also asked to rank nine currently relevant cross-cutting topics (ESD, language education, environmental education, cultural education, digitization, migration, STEM education, inclusion, and gender mainstreaming) according to their relevance in their own teaching. Environmental education and ESD were rated as topics of the highest or very high relevance. Accordingly, teachers also largely agreed (on a four-point Likert scale, in which, again, higher values indicated stronger agreement) that ESD should be addressed in as many subjects as possible (M = 3.12, SD = 0.86).

In addition, differences were found in the personal value which teachers ascribed to ESD depending on the different subject cultures. As an indicator to assess teachers' personal value of ESD, we used the statement *There is no room for more ESD in today's overloaded curricula*. Teachers who taught natural or social science subjects with a stronger connection to ESD (e.g., biology, geography, social studies) agreed with this statement to a greater extent (M = 2.22, SD = 0.96) than teachers teaching cultural science subjects (e.g., German, history) (M = 1.78, SD = 0.83). This mean difference between teachers from these two different subject cultures was significant ($T(106) = 2.27$, $p = 0.025$) and can be classified as a small effect size (d = 0.49).

Behind this relatively high personal significance which teachers reported, the level of their knowledge of ESD, their participation in ESD further training courses, and the situation at their schools somewhat lagged behind. The Global Action Programme launched by UNESCO [57] as a follow-up to the World Decade of Education for Sustainable Development (UN DESD) [58] proclaimed by the United Nations was known to only about 20% of the teachers in our survey and, for the most part, without being able to name its concrete goals or contents. Only 15% had attended an ESD-related further training course in the past three years. Teachers largely agreed with the statements that ESD is important at their own school (M = 2.64, SD = 0.82) and that the school administration promotes ESD-related teaching projects (M = 2.80, SD = 0.87) (both assessed on a four-point scale, in which higher values indicated stronger agreement).

### *4.3. Correlational Analyses: Connecting the Students' and the Teachers' Level*

As a first approximation of linkages between teacher characteristics (e.g., attitudes and experiences related to ESD) and student outcomes (RQ 2), we analyzed the bivariate correlations between teacher-related characteristics and students' average achievement gains at the aggregated classroom level as well as their developments in attitudes and behavior from the beginning of the school year (T1) towards the end of the school year (T2).

As displayed in Table 3, significant correlations emerged between teachers' participation in ESD further training courses and student-level characteristics: accordingly, contrary to our expectations, students whose teachers participated in ESD further training courses showed significantly lower average changes in their sustainability-related knowledge, their affective-motivational beliefs and attitudes towards sustainability, and their self-reported sustainability-related behavioral intentions over the course of the school year than students whose teachers did not participate in such further training courses. According to Cohen [59], these correlations can be considered as small effects (knowledge, attitudes) or medium effects (behavior).

**Table 3.** Correlations between changes in students' sustainability-related knowledge, affective-motivational beliefs and attitudes towards sustainability, and self-reported sustainability-related behavioral intentions and different dimensions of teachers' professional knowledge.

| | | Knowledge [1] | Beliefs and Attitudes [2] | Behavioral Intentions [3] |
|---|---|---|---|---|
| Environmental and sustainability awareness | r | −0.01 | −0.02 | −0.05 |
| | p | 0.93 | 0.85 | 0.70 |
| Teacher's individual value of ESD | r | −0.07 | −0.07 | 0.06 |
| | p | 0.61 | 0.61 | 0.62 |
| Value of ESD at school | r | 0.13 | −0.15 | 0.03 |
| | p | 0.29 | 0.25 | 0.84 |
| Self-efficacy towards ESD | r | −0.10 | −0.13 | 0.12 |
| | p | 0.45 | 0.32 | 0.33 |
| Participation at further training on ESD | r | −0.26 * | −0.28 * | −0.35 *** |
| | p | 0.04 | 0.02 | 0.00 |
| Knowledge of ESD [4] | r | 0.01 | −0.06 | 0.06 |
| | p | 0.96 | 0.65 | 0.64 |
| Practice of ESD in teaching [4] | r | 0.23 † | 0.12 | −0.15 |
| | p | 0.07 | 0.34 | 0.25 |

*Notes.* Correlations (Pearson's r) at the teachers' level (n = 63 classes). [1] Average achievement gains at the classroom level between the beginning (T1) and end of the school year (T2). [2] Average change at the classroom level in students' affective-motivational beliefs and attitudes towards sustainability between T1 and T2. [3] Average change at the classroom level in students' self-reported sustainability-related behavioral intentions between T1 and T2. [4] 1 = *no*; 2 = *yes*. Significance (two-tailed): *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.10$.

### *4.4. Multilevel Analyses: Students' Development of Sustainability Competencies within One School Year*

Multilevel analyses were performed in separate estimation models, with the three different indicators of sustainability competencies at the individual level as dependent variables (Model I: sustainability-related knowledge, Model II: affective-motivational beliefs and attitudes towards sustainability, and Model III: self-reported sustainability-related behavioral intentions).

To predict students' sustainability competencies, we included predictors at two different analysis levels: At the individual level (student level), we considered four different predictor sets:

1. Sociodemographic characteristics: students' gender (values for boys and girls were estimated separately, reference: *diverse*), immigrant background (operationalized by students' language spoken at home, reference: *foreign language/other language than German*), and grade point average (GPA) as an indicator of students' achievement (GPA in German, Mathematics, and Science, z-standardized at the grand mean [M = 0, SD = 1]);
2. Prior assessment at the beginning of the school year (z-standardized at grand mean, with M = 0, SD = 1);
3. ESD-related characteristics: participation in Fridays for Future activities (0 = *no*; 1 = *yes*), knowledge of the sustainability concept (0 = *no or very little knowledge of the sustainability concept*; 1 = *profound knowledge of the sustainability concept and being able to explain it to others*); and
4. School-related characteristics: grade level (reference: *Grade 5*) and attended school track (reference: *basic track [Werkrealschule]*).

Similarly, at the teachers' level, different predictor sets were included:

1. Sociodemographic characteristics: teachers' gender,
2. Teachers' attitudes towards ESD, and
3. Teachers' professional knowledge of ESD

Regarding the dependent variables, we predicted students' assessment of sustainability competencies at the end of the school year (T2) while simultaneously controlling for

their assessment values at the beginning of the school year (T1). The resulting values could thus be interpreted as the development of students' sustainability competencies over the course of the school year.

In a first step, in a completely unspecified model without any predictors (so-called empty model), the variance in the dependent variables was decomposed into two variance components, which referred to differences between students (individual level) and to differences between the classes (teachers' level). This allowed us to examine whether there were any between-classroom differences in students' sustainability competencies at all.

In a second step, the above-mentioned predictors were added at the lower analysis level of the students and, respectively, at the higher level of teachers in order to analyze whether and to what extent these variables could predict differences between classes. Significant effects indicated which student or teacher characteristics (considering the respective baseline value (T1) of knowledge, attitudes, or behavior) could contribute to a more favorable (positive sign) or a less favorable (negative sign) development of the students over the course of the school year.

Multilevel models were specified as random intercept and random slope models: by doing so, both the intercept could vary between students and the slopes could vary across classes. Thus, we assumed not only differences in the average value of the respective dependent variable between the classes, but we also assumed that the student-level effects of each predictor variable varied between classes.

#### 4.4.1. Variance Decomposition

The empty model contained only one fixed effect (intercept) and random effects at both analysis levels but no explanatory variables [60]. This step was necessary to divide the total variance of the dependent variables between the two analysis levels, i.e., the variance of students' sustainability competencies was divided into a variance component within (level 1) and between aggregate units (level 2). This model was used to determine the intraclass correlation coefficient (ICC), which indicates the proportion of the total variance that was accounted for by differences between classes [ibid.].

First, the variance decomposition (Table 4) in a completely "empty" model without any predictors showed that 62% of sustainability-related knowledge at the end of the school year was due to differences between the individual students within the school classes, while 38% could be attributed to differences between the examined classes. The respective variance component at the aggregate level turned out to be significant.

**Table 4.** Decomposition of variance of students' sustainability competencies.

| | **Variance Components** [1] | | | | | |
|---|---|---|---|---|---|---|
| | **Level 1 ($\sigma^2$)** | **Level 2 ($\tau_{00}$)** | **ICC** [2] | **Deviance** [3] | **df** | ***p*** |
| Knowledge | 0.65145 | 0.39890 | 0.380 | 2995.42 | 62 | <0.001 |
| Beliefs and Attitudes | 0.88607 | 0.11644 | 0.116 | 3278.82 | 62 | <0.001 |
| Behavioral Intentions | 0.88867 | 0.11522 | 0.115 | 3281.68 | 62 | <0.001 |

*Notes.* [1] Level 1: Student level; level 2: classroom level. [2] Intraclass correlation coefficient. ICC = $\tau_{00}/(\tau_{00} + \sigma^2)$. [3] Deviance: –2LogLikelihood (–2LL).

Compared to students' sustainability-related knowledge, the proportion of variance accounted for by the class level was smaller for their affective-motivational beliefs and attitudes towards sustainability, but again, it was significant: regarding the attitude-related dimension of sustainability competencies, 11.6% of the variance could be explained by differences between classes. Finally, the share of variance at the classroom level for the behavioral dimension was of a comparable magnitude (11.5%).

Thus, as a first result, it could be concluded that the classrooms in our sample indeed differed regarding students' sustainability-related knowledge, their affective-motivational beliefs and attitudes towards sustainability, as well as their self-reported sustainability-related behavioral intentions. Even though the extent of variance at the aggregate level varied by the three different indicators of sustainability competencies, significant differ-

ences between classes could be detected for all three aspects, suggesting the need for more in-depth multilevel analyses considering predictors at the individual and class level. With such an approach, we could analyze the contribution which student and teacher characteristics make to explain unequal developmental trajectories.

#### 4.4.2. Prediction of Sustainability Competencies by Student and Teacher Characteristics

In Table 5, the results of the multilevel analyses are reported for each of the dependent variables at the end of the school year, controlling for predictors at the student level, including, amongst others, the respective measurement at the beginning of the school year, and at the teachers' level in the fully specified estimation models. In addition, it was also examined whether alternative model specifications changed the goodness of the model fit. For all three dependent variables, the fully specified model led to a significant model improvement compared to the empty model ($p < 0.001$). With respect to the aggregate-level variables, we considered all of the characteristics listed in Table 5 simultaneously as the final model showed the best goodness of fit compared to other model specifications and as our central concern was to apply the same estimation model to the three different dimensions of sustainability competencies.

##### Predicting Students' Sustainability-Related Knowledge

For the dimension of sustainability-related knowledge (Model I), students' gender (advantage of girls over diverse gender), GPA, and prior knowledge at the beginning of the school year were found to be significant predictors at the individual level. As could have been expected from other findings in school effectiveness research, prior knowledge (assessment at T1) was the strongest predictor, along with students' grade level and the attended school track. Controlling for other variables, students' sustainability-related knowledge seemed to increase with increasing grade levels, with students in Grade 8 differing in particular from those in Grade 5. In addition, we observed track-specific developments of students' sustainability-related knowledge, with the greatest advantages for students at academic tracks (*Gymnasium*), while those attending comprehensive tracks (*Gemeinschaftsschule*), even when controlling for prior knowledge, showed a significantly lower performance compared to students at basic tracks. Students who participated in Fridays for Future activities as well as those showing an understanding of the sustainability concept were found to have a significantly higher sustainability-related knowledge at the end of the school year.

At the teachers' level, it was found that students whose teachers reported to put a high emphasis and priority on ESD at school had a higher level of knowledge. Students, however, who were taught by teachers reporting that they taught ESD topics showed, contrary to our expectations, a lower knowledge development over the course of one school year compared to other schoolmates whose teachers did not teach ESD-related topics.

Overall, the characteristics considered in Model 1 explained about one-third of the variance in sustainability-related knowledge at the end of the school year at the individual level ($R^2 = 0.327$) and about 90% of the variance ($R^2 = 0.895$) at the classroom level. Compared to the completely unspecified model (null model), a significant improvement of the goodness of fit was achieved by including the considered predictors in the estimation model ($p < 0.001$). With this model specification, it became obvious that the considered variables are relevant predictors of students' development of sustainability-related knowledge over the course of the school year.

**Table 5.** Prediction of sustainability-related knowledge, affective-motivational beliefs and attitudes towards sustainability, and self-reported sustainability-related behavioral intentions by student and teacher characteristics.

| | (I) Knowledge (T2) | | (II) Beliefs and Attitudes (T2) | | (III) Behavioral Intentions (T2) | |
|---|---|---|---|---|---|---|
| | β | (SE) | β | (SE) | β | (SE) |
| Intercept | −0.78 * | (0.33) | 0.33 | (0.35) | 0.30 | (0.34) |
| *Student level* | | | | | | |
| *I. Sociodemographic characteristics* | | | | | | |
| Gender [1] | | | | | | |
| female | 0.30 * | (0.14) | 0.34 | (0.31) | 0.06 | (0.21) |
| male | 0.21 | (0.15) | 0.07 | (0.31) | −0.13 | (0.22) |
| Immigrant background [2] | 0.12 | (0.07) | 0.11 | (0.09) | −0.30 ** | (0.09) |
| GPA [3] | −0.11 *** | (0.02) | −0.12 ** | (0.04) | −0.12 *** | (0.03) |
| *II. Assessment T1* | 0.42 *** | (0.03) | 0.47 *** | (0.03) | 0.46 *** | (0.02) |
| *III. ESD-related characteristics* | | | | | | |
| Participation at Fridays for Future activities | 0.17 ** | (0.06) | 0.16 * | (0.08) | 0.22 ** | (0.08) |
| Knowledge of sustainability concept | 0.26 *** | (0.06) | 0.14 * | (0.06) | 0.09 | (0.07) |
| *IV. School-related characteristics* | | | | | | |
| Grade level [4] | | | | | | |
| Grade 6 | 0.21 *** | (0.06) | −0.02 | (0.07) | 0.05 | (0.05) |
| Grade 7 | 0.21 *** | (0.06) | −0.22 ** | (0.07) | −0.27 *** | (0.08) |
| Grade 8 | 0.39 *** | (0.06) | −0.14 | (0.09) | −0.16 | (0.09) |
| Track [5] | | | | | | |
| Comprehensive track | −0.34 ** | (0.11) | −0.09 | (0.13) | −0.14 | (0.11) |
| Intermediate track | 0.06 | (0.11) | −0.04 | (0.11) | −0.02 | (0.07) |
| Academic track | 0.33 ** | (0.11) | 0.09 | (0.12) | 0.07 | (0.07) |
| *Teachers' level* | | | | | | |
| *I. Sociodemographic characteristics* | | | | | | |
| Gender: female [6] | 0.04 | (0.05) | 0.06 | (0.06) | 0.06 | (0.06) |
| *II. Teachers' attitudes towards ESD* | | | | | | |
| Environmental and sustainability awareness | −0.07 | (0.04) | −0.13 * | (0.06) | −0.06 | (0.06) |
| Teacher's individual value of ESD | −0.02 | (0.05) | 0.02 | (0.06) | −0.13 * | (0.06) |
| Value of ESD at school | 0.09 ** | (0.03) | −0.05 | (0.04) | −0.06 † | (0.03) |
| Self-efficacy towards ESD | −0.04 | (0.04) | 0.01 | (0.04) | 0.16 ** | (0.05) |
| *III. Professional knowledge regarding ESD* | | | | | | |
| Participation at further training on ESD [7] | −0.04 | (0.06) | −0.16 * | (0.07) | −0.26 ** | (0.08) |
| Knowledge of ESD [7] | −0.05 | (0.03) | 0.01 | (0.06) | 0.05 | (0.06) |
| Practice of ESD in teaching [7] | −0.17 * | (0.07) | 0.02 | (0.10) | −0.05 | (0.09) |
| *Model fit* ($R^2$) | | | | | | |
| Student level | 0.327 | | 0.370 | | 0.337 | |
| School level | 0.895 | | 0.349 | | 0.375 | |
| Improvement of model fit [8] | <0.001 | | <0.001 | | <0.001 | |

*Note.* Dependent variables: Assessment of students' sustainability-related knowledge (Model I), affective-motivational beliefs and attitudes towards sustainability (Model II), and self-reported sustainability-related behavioral intentions (Model III) at the end of the school year (T2). Standardized regression coefficients (β); standard errors (SE) in brackets. References: [1] diverse. [2] Language spoken at home: German. [3] GPA: Grade point average. [4] Grade 5. [5] Basic track. [6] male. [7] no. [8] Improvement of the model fit compared to the empty model without any predictors (for variance decomposition). Continuous predictors (GPA, assessment T1) z-standardized at the student level (M = 0, SD = 1). *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.10$.

Predicting Students' Affective-Motivational Beliefs and Attitudes towards Sustainability

Regarding the development of affective-motivational beliefs and attitudes towards sustainability (Model II), at the student level, gender did not, in contrast to knowledge development, prove to be a significant predictor. However, students' GPA, their sustainability-related attitudes at the beginning of the school year (assessment at T1), participation in Fridays for Future, and knowledge of the sustainability concept as well as grade level were again significant predictors of their affective-motivational beliefs and attitudes towards sustainability at the end of the school year. Concerning the grade level, we observed that students in Grade 7 showed significantly lower affective-motivational beliefs and

attitudes towards sustainability than those in Grade 5, whereas there were no significant differences for students in Grade 6 and Grade 8, respectively, compared to the reference group. In contrast to students' knowledge trajectories, their affective-motivational beliefs and attitudes towards sustainability did not show differential developments depending on the attended school track.

At the teachers' level, their reported environmental and sustainability awareness and their participation in further training on ESD could be identified as significant predictors of students' affective-motivational beliefs and attitudes towards sustainability; however, both of these were contrary to our expectations in a negative direction. This means that students' affective-motivational beliefs and attitudes towards sustainability at the end of the school year were more favorable the lower their teachers' environmental and sustainability awareness was and the fewer teachers participated in further training on ESD. Once again, it should be pointed out that the data at the teachers' level was collected as self-reports and self-assessments. Thus, we were not able to determine the quality of ESD training courses, for example. It might be possible that there were selection effects regarding the attendance of ESD training courses, so that maybe teachers who perceived themselves as less competent in the field of ESD were those who attended such training courses. With regard to the effects of teachers' environmental and sustainability awareness, students' affective-motivational beliefs and attitudes towards sustainability at the end of the school year were more favorable the lower the reported values for environmental and sustainability awareness by their teachers. At this point, it can only be speculated that maybe too pointed statements by teachers regarding their own environmental and sustainability awareness could possibly lead to reactance in the sense of some kind of inner resistance in students' own attitudes. However, these assumptions are only speculative.

Overall, the characteristics which we considered here to predict students' affective-motivational beliefs and attitudes towards sustainability could, nevertheless, explain more than one-third of the variance in students' attitudes at the end of the school year, both at the individual level ($R^2 = 0.37$) and the aggregate level ($R^2 = 0.35$). Compared to the completely unspecified (empty) model, with the predictors taken into account here, a significant improvement of the model fit was achieved ($p < 0.001$). Again, the full model specification highlighted that most of the considered variables were relevant predictors of students' development of affective-motivational beliefs and attitudes towards sustainability over the course of the school year.

Predicting Students' Self-Reported Sustainability-Related Behavioral Intentions

In Model 3, students' immigrant background and their self-reported sustainability-related behavioral intentions at the beginning of the school year (assessment at T1) were significant predictors of their behavioral intentions at the end of the school year. Students who reported not speaking German as their first language showed lower sustainability-related behavioral intentions than students whose first language was German, controlling for all other variables. In addition, significant effects were also observed for students' participation in Fridays for Future activities as well as for their GPA. For school-related characteristics, grade-specific differences were observed but only with students in Grade 7 exhibiting significantly less sustainability-related behavioral intentions than students in Grade 5. For the other grades, however, no specific advantages or disadvantages emerged when simultaneously controlling for all other variables in the model. Similarly, track affiliation did not prove to be a relevant predictor in this model.

At the teachers' level, the personal value teachers placed on ESD and the number of ESD training sessions attended were found to be significantly negative (!) predictors, whereas self-efficacy attitudes towards ESD exerted a significant positive effect on students' self-reported sustainability-related behavioral intentions.

Overall, the characteristics considered for this dimension of sustainability competencies explained about one-third of the variance in self-reported sustainability-related behavior at the end of the school year at the individual level ($R^2 = 0.34$) and slightly more

than one-third of the variance ($R^2 = 0.38$) at the school level. Compared to the completely unspecified model, a significant improvement in model fit was also achieved here with the included predictors ($p < 0.001$).

## 5. Discussion of the Main Findings

The present paper examined, first, the development of students' sustainability-related knowledge, their affective-motivational beliefs and attitudes towards sustainability, and their self-reported sustainability-related behavioral intentions over the course of one school year (Research Question 1). Second, we analyzed whether and how teacher characteristics hereby make a difference, with the aim to identify possible fostering and hindering factors for students' development (Research Question 2). For analyses, we drew on data from a stratified sample of 10 secondary schools of different school tracks in Baden-Wuerttemberg (Germany). Students (Grade 5–8) and their teachers participated in our study (conducted in the school year 2018/2019).

Regarding the development of sustainability competencies over the course of one school year (Research Question 1), results indicated a significant increase in students' sustainability-related knowledge and a decrease in their affective-motivational beliefs and attitudes towards sustainability. Students' self-reported sustainability-related behavioral intentions did, however, not change. Hence, Hypothesis 1, which assumed a positive development of students' sustainability competencies, could only partly be supported, with the results varying with the respective dimension of sustainability competencies.

Regarding Research Question 2 (association between teacher- and school-related characteristics and students' competence development), a higher value of ESD at school seemed to be significantly positively related to the development of the students' sustainability-related knowledge. This finding supports the relevance of school development measures to raise the overall status of ESD at the school. Similarly, the higher teachers' self-efficacy towards ESD, the more favorable was the development of students' self-reported sustainability-related behavioral intentions.

Contrary to our expectations, the ESD content already covered by the teacher in class (reported ESD practice) seemed to have a negative effect on students' sustainability-related knowledge. Hence, the evaluation of Hypothesis 2 depends on the considered student and teacher characteristics. The multilevel analyses thus showed that the considered variables were relevant predictors of the development of self-reported sustainability-related behavioral intentions. When interpreting the results of the multilevel analyses, however, it should be noted that the effects in each case only applied when all other variables were considered simultaneously. The estimations were thus the "net effects" of the variables that were statistically adjusted for the effect of the other variables. Nevertheless, based on the findings of the present study, we could not make any statement about the quality of the implementation of the ESD content (on the part of the teachers). Beyond this, our study revealed that the examined characteristics at the teachers' level seemed to be differentially predictive of different student outcomes, with the effects varying in size and significance depending on the examined outcome variable (supporting Hypothesis 3).

Successful conditions for the development of sustainability competencies could be attributed to this. Therefore, it could be useful to empirically investigate the contents, procedures, and quality of ESD-related lessons but also the extracurricular factors, such as the significant influences of Fridays for Future. Teacher attitudes and the number of training sessions did not seem to be related to the development of sustainability-related knowledge. The environmental and sustainability awareness of the teachers even had a rather counterproductive effect on students' sustainability-relevant attitudes and beliefs. The personal value of ESD for the teacher was also negatively related to the development of behavioral intentions among the learners. It can be assumed that there might be reactance effects with regard to students' attitudes and behavioral intentions if the teacher's teaching activities are too much influenced by his or her own attitudes. Furthermore, it is likely that especially in this phase of students' development, environments outside of school (e.g., peers or (social) media)

exert a considerable influence on attitudes and behavioral intentions, so that the school's possibilities for influencing them must be considered realistically limited from the outset. However, the promotion of students' sustainability-related knowledge should also contribute in an acceptable way to the fact that they develop, possibly in the long term, informed and self-responsible ESD-related positive attitudes and behavioral intentions. The pedagogical effect of ESD in schools will probably not be successful without taking into account the non-school environment. With regard to the unexpected direction of the effect of the attended ESD further training courses, while at the same time the teachers expressed the wish for more trainings, a detailed investigation of the extent and frequency (quantity), the quality (consideration of findings from empirical educational research), the methodological procedures, and the framework conditions (e.g., one-day or multi-day trainings, training for individual teachers or the entire staff) might be helpful. Further analyses regarding teacher training programs in other German states [61] and recommended means in the ESD literature [62] have revealed an alarming lack of knowledge of robust findings from empirical educational research on effective means (e.g., instructional procedures and methods to promote knowledge, attitudes, and behavioral readiness) and on the formulation of verifiable ESD goals [9,10]. The claim that ESD requires a completely new and distinct learning culture, which is particularly common in ESD, must be rejected as ideologically based until contrary findings can be presented. This is because the only positive, i.e., supportive, condition on the part of the teacher, apart from the value of ESD for the school, is the ESD-related self-efficacy expectations of the teacher. These reinforce the likelihood of positive experiences. Therefore, instead of focusing too much on changing teachers' attitudes, measures could be taken to promote the implementation of ESD through appropriate and appealing materials, which in turn, could increase the feeling of self-efficacy.

Evaluating the significance of the presented findings, some limitations should be considered. First, the examined predictors were partly based on both students' and teachers' self-reports. Second, our study was based on a comparatively small teacher sample. However, it was a random sample, and we focused on those teachers who taught in the examined classes, which allowed us to relate teachers' characteristics as predictors of students' outcomes. By doing so, both fostering and hindering effects at the individual and classroom level for students' development of sustainability competencies could be identified.

To conclude, with the presented possibilities of measurement and the empirical data already generated and to be collected in the future, further insights into successful ESD implementation at school and the associated conditions of success can be gained in greater perspective. Quantitative and methodologically sound research projects can, therefore, with the inclusion of qualitative data, make a very important contribution to the normative debate far beyond purely empirical analyses.

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how their data would be used, if there were any risks associated, and that no disadvantages would result from non-participation.

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