"Sustainable" Is Synonymous to "Eco-Friendly": Student Perceptions about Sustainability and Sustainable Behavior

Sonja T. Fiedler[1,2]* , Thomas Heyne[3], Franz X. Bogner[2]

[1]Didactics of Biology, University of Würzburg, Würzburg, Germany
[2]Z-MNU (Centre for Math & Science Education), University of Bayreuth, Bayreuth, Germany
[3]PSE (Professional School of Education), University of Würzburg, Würzburg, Germany
Email: *Sonja.fiedler@uni-wuerzburg.de

Abstract

Education for Sustainable Development (ESD) is a designated goal of the UN and by now an integral part of modern curricula. ESD programs grounded in student perceptions are considered the ideal starting point for effective learning progress. Although various studies about the student conceptions in ESD contexts exist, little data is available about younger age groups. This cross-sectional study is supposed to extend insight into adolescent perceptions on sustainability and sustainable behavior by providing a systematic analysis of students' ($N = 139$, age 10.2 ± 0.28) perceptions. A suitable category system needed establishment first. On that basis substantial knowledge gaps regarding the three pillars of sustainability were identified: economic and social aspects were rarely addressed. Most students had encountered the term "sustainable" in the media first. The dominant category was "examples for sustainable behavior". The terms *sustainable* and *eco-friendly* appear to be used synonymously by the students. Based on conceptual preferences, implications for further research and concepts for student-centered ESD teaching are provided.

1. Introduction

The *Sustainable Development Goals* (SDGs) are part of the UN's *Agenda 2030*, which addresses global issues such as climate change, poverty, and inequality.

Education for Sustainable Development (ESD) is regarded a powerful tool to achieve the SDGs (UNESCO, 2017). Implementing ESD elements in syllabi has been advanced by the *Decade of Education for Sustainable Development*. However, the *Sustainable Development Goals Report 2017*, describes "the rate of progress in many areas far slower than needed to meet the targets by 2030" (UNSD, 2017: p. 4). Likewise, studies on ESD elements in the German school system reported gaps in curricula and irregularities between school types (Singer-Brodowski et al., 2019). In some states curricula have been adapted and expanded to include key ESD content (Bayerisches Staatsministerium für Unterricht und Kultus, 2014). To what extent this content is implemented in the classroom and adopted by the students, remains to be clarified. Especially the students' understanding of sustainability as a multidimensional construct should be considered.

1.1. ESD and *Sustainability*

The term *sustainability* is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987: p. 4). This initial classification has been refined by identifying 3 key areas of sustainable action, namely ecology, economy and social matters (Imran et al., 2014). The SDGs demonstrate that sustainable action and ESD involve many different issues and are considered an interdisciplinary field of research (Sund & Gericke, 2020). Sustainable development encompasses aspects such as: 1) social progress, which recognizes the needs of everyone; 2) effective protection of the environment; 3) prudent use of natural resources, and 4) maintenance of high and stable levels of economic growth and employment (DETR Report, 2000). Apart from political guidelines, however, there are also different research approaches with regard to sustainability concepts. For example, "strong sustainability" is an approach to sustainable development that emphasizes the need to maintain or enhance the stock of natural capital, such as biodiversity, ecosystems, and non-renewable resources. It argues that human well-being is dependent on the preservation of ecological systems and that economic development should not come at the expense of environmental degradation (Ekins et al., 2003; Liobikiene et al., 2019). Other researchers focus on the social and planetary boundaries in interaction with and relation to ecological and economic aspects (Norström et al., 2020). Although sustainability has been established as a multidisciplinary concept, studies show that ecological aspects are paramount (Benninghaus et al., 2018; Stössel et al., 2021; Walshe, 2013). The term *sustainable* is often used synonymously with *environmentally friendly* by young students (Raab & Bogner, 2021; Walshe, 2013). Thus, little perceptions on economic and social aspects of sustainability are expected.

Studies have revealed a correlation between sustainability knowledge, attitudes, and behaviors. Emotions can strongly influence behavior and high knowledge scores can positively influence pro-environmental attitudes (Carmi et al., 2015; Faize & Akhtar, 2020; Geiger et al., 2019; Maurer et al., 2020). Derived

from this, establishing in-depth sustainability knowledge should motivate learners to live more sustainable lifestyles. However, discrepancies were revealed between the knowledge of environmentally harmful actions and its practical implementation into everyday-life (Keselman et al., 2012). For example, people share knowledge about the global danger of biodiversity loss yet do not act accordingly unless a viable threat to their current lifestyle, such as shortages in basic food items, is imminent. People know exactly what sustainable behavior means, but manifest binary perceptions of sustainable lifestyles (Kowasch & Lippe, 2019). Therefore, one task of sustainability research is to determine which sustainability concepts and ideas on sustainable lifestyles prevail. These concepts serve as a basis for effective ESD, on the one hand by identifying topics and knowledge gaps regarding various target groups, and on the other hand by providing action-oriented approaches. Such holistic approaches should also take into account that there seems to be a different disposition for action between men and women with regard to sustainability.

1.2. Gender and *Sustainability*

Gender differences in sustainability knowledge, attitudes, and actions were uncovered across a range of topics. These include gender equality as part of sustainable development itself, differences in consumer behavior, as well as attitudes towards the importance of the topic as such (Bloodhart & Swim, 2020). With regard to the ecological aspects of sustainable behavior, it has been demonstrated that women tend to exhibit more pro-environmental behavior (PEB) than men (Dzialo, 2017). Women also tend to be more receptive towards more sustainable and environmentally friendly behavioral changes relative to men (Newman & Trump, 2023). Various approaches have been proposed to motivate men to display more PEBs (Rainisio et al., 2022). Regarding educational contribution to promote PEBs, it is assumed that these gender differences should either be prevented by addressing them early on in elementary school syllabi or choose gender-appropriate topics for students in adolescent education. Since it is not yet clear at what age such gender differences begin to manifest, one goal of this study is to find out whether they are already measurable in fifth graders.

1.3. Student Perceptions and *Sustainability*

Following a constructivist perspective of learning, students are actively structuring their knowledge based on individual skills and experiences (Piaget, 1964). Although a wide variety of constructivist teaching approaches exists, one consensus remains: learning is an active process based on the individual characteristics of the learner (de Kock et al., 2004). The realization of this core statement varies widely (Bodner et al., 2001). Scientists agree, however, that besides physical and social prerequisites, prior-experiences and prior-knowledge play a major role in the learning process (Driver, 1989; Posner et al., 1982). Prior to entering

the classroom, students can hold "naïve" perceptions before they are confronted with "professional" perceptions. Naïve student perceptions influence the integration of new ideas. Conceptual change research suggests that a variety of concepts can exist for the same topic. However, even if these concepts contradict each other, they do not necessarily need to be replaced, but can co-exist (Boyes & Stanisstreet, 1990; Thorn et al., 2016). This is especially true for every-day perceptions that explain phenomena on a superficial, oversimplified level (Schauss & Sprenger, 2021). Such misconceptions can undermine ESD efforts as learners cling to these in everyday contexts and apply scientifically proven concepts only in educational environments. For example, studies regarding perceptions about biodiversity loss revealed that students acknowledge biodiversity conversation as important, yet do not seem to be aware of their own harmful actions (Kilinc et al., 2013). This results in less pro-environmental behavior (Cimer et al., 2011; Kaiser & Roczen, 2008). The conceptual change theory provides approaches to change nonscientific perceptions into scientific ones (Posner et al., 1982). One crucial element of this modification is to target pre-existing concepts directly. Therefore, it is essential for educational research to determine empirically which misconceptions are prevalent. A better understanding of students' perceptions helps teachers effectively address them in ESD teaching. Identifying students' existing perceptions in empirical studies is thus an essential prerequisite for effective teaching and learning.

Student perceptions can be surveyed by different methods: interviews (Lucero et al., 2020; Opitz et al., 2017), open-ended questions (Jaimes et al., 2020; Schneiderhan-Opel & Bogner, 2019), concept-maps (Walshe, 2008), or multiple-choice questions (Hoppe et al., 2020). Interviews and closed-ended questions are appropriate when the topic has been extensively researched and questionnaires items can be deduced from literature review (e.g. in Ayene et al., 2019; Fidalgo et al., 2020; Walters et al., 2022). To the best of the authors' knowledge, few studies on students' perceptions of sustainability have been published. Most of these studies focus on specific sub-areas, such as energy, waste management, biodiversity, climate change and sustainable nutrition (Dornhoff et al., 2020; Opitz et al., 2017; Schauss & Sprenger, 2021; Schmid & Bogner, 2018b). Therefore, the primary aim of this study was to explore students' general perceptions of "sustainability" to compare them to professional perceptions and derive implications for teaching practice.

This study provides an important contribution to current research as students of our age group were rarely interviewed due to the strict requirement of administrational permission. For practical reasons, a large proportion of studies on student perceptions use freshmen whose perceptions are assumed to be equivalent to high school students. In consequence, our study followed the difficult way of sampling in school despite of the need of special permission from the Ministry of Education. In addition, we regard it important to know the circumstances of sampling as for many online questionnaires it is not entirely clear

whether students completed them on their own when surveys were finalized at home.

To conclude, while sustainable action is internationally recognized as an important educational goal, its practical implementation in schools needs to be strengthened as part of the effort to meet the SDGs. One approach to creating effective learning environments is to assess students' prior knowledge and experiences and integrate them into the relevant lessons. To date, little information is available in this research area about the target group we have chosen. It could also be useful to consider differences in the gender of the students, as women seem to be more inclined to act in an environmentally friendly and thus sustainable way.

1.4. Research Questions

Since the current state of research in this age cohort does not show any categories for student perceptions of sustainability, a category system had to be established and validated first. This resulting category system was analyzed in detail and possible sources of information on the part of the students were identified. Subsequently, the results were compared within the sample, i.e., in relation to gender and school. The following research questions guided the analysis:

1) What student perceptions do 5th graders hold about sustainability and sustainable behavior?

2) What gender differences can be identified in 5th graders regarding sustainability concepts?

2. Materials and Methods

2.1. Sample and Data Collection

139 Bavarian 5th-graders (10.2 ± 0.28 years, 43% ♀) completed 4 open-ended questions in a paper-pencil test. The students were part of a random sample from southern German urban areas. Participation in the study was voluntary and took place at school during school hours. Three classes each at three different schools in different cities were surveyed. The questions shown in Table 1 were validated in a previous pilot study with 88 students. For this purpose, the pilot group was divided into 2 subgroups, which answered a different selection

Table 1. Questions for concept-retrieval.

Question	Wording
Q1	What does the term "sustainability" mean to you? Name 2 examples for sustainable behavior.
Q2	Is living sustainably important? Give reasons why/why not.
Q3	Explain differences between sustainable and non-sustainable agriculture.
Q4	What would you change to live a more sustainable lifestyle? Provide examples.

of questions. The grouping was based on school grades, so it can be assumed that the two subgroups operated at a similar level of knowledge and therefore represented comparable groups. Subsequently, the questions that provoked the most elaborated answers were selected.

2.2. Development of the Category System

The category system was developed according to qualitative content analysis (Bos & Tarnai, 1999; Mayring, 2015). First, some categories were developed deductively based on literature review. This initial draft of the category system was tested with about 10% of the data set. If items did not fit into any category but their inclusion seemed relevant, new categories were added. This process was repeated three times. A coding guideline with a clear definition of every category and an anchor example for each category was provided. Table 2 displays an excerpt of the coding guidelines.

Three raters who had not previously processed the data set were introduced to the category system through a coding guide. 30% of the data was rated by two independent raters and the entire data set by another rater to determine inter-rater reliability. The latter was repeated two months later to determine intra-rater reliability. Cross-matching of the results was then used to validate the category system. Due to the very good concordance, the validation process was considered complete. Categories that were affected by less than 3% of the data were now grouped together as "others" to simplify the system.

2.3. Reliabilities

Intra- and inter-rater-reliability tests were conducted to validate the category system. One rater rated the whole set of students twice within 2 months (Cohen's $K = 0.93$). Two other raters rated the same 30% of the dataset. Their results were compared to each other as well as the first rater (Cohen's $K = 0.81, 0.82$ and 0.89). The resulting Cohen's kappa scores in the range of 0.81 - 1.00 indicate an "almost perfect" agreement between the raters (Cohen, 1960; Landis & Koch, 1977).

Table 2. Examples for categories, their definition and anchor examples from the category system.

| Category	Definition	Anchor Example
Generation	Refers to future generations, their needs etc.	"You should live in a way that your children can live that way, too."
Climate Change	Refers to actions for more climate protection, to stop climate change,	"We need more climate protection."
Locomotion	Refers to any kind of (human) transportation	"We should ride our bicycles more and use the car less."
Recycling	Refers to waste separation as well as reusable materials	"We need good waste separation to protect our oceans."

3. Results

53.24% of students reported knowing the term sustainability from television or other media. 35.97% stated that they knew it from school. Multiple answers were possible in closed questions. A total of 1001 items was processed. This study first looks at the global breakdown of all questions across the main categories and then attempts to look at individual subcategories in more detail. This procedure was chosen to allow follow-up studies in which the same questions are to be asked in different grades. This should provide information about how persistent student ideas about sustainability topics are and whether the sustainability topics of the curriculum are reflected in the student ideas. Therefore, a detailed analysis of the individual subcategories within the scope of this analysis seems useful in order to specify these very subcategories for a larger-scale survey. With a larger amount of data, it will then be possible to look at the extent to which each question, considered individually, varies across the different subject areas. However, this procedure would go beyond the scope of the present paper.

3.1. Main Categories

The main categories were "Definition", "Example", "Other" and "Not Usable". 57% of the items were coded as "Example", 17% were classified as "Definition" (see Figure 1). 20% of the items were coded as "not usable", which includes non-related utterances such as "I don't know". 6% of utterances were defined as "other", which means they were topic-related but did not fit any of the categories.

3.2. "Definition" Category

Item counts for "Definition"-subcategories throughout all 4 questions were "eco-friendly" (48%), "climate change" (27%), "planet-friendly" (19%) and "generation"
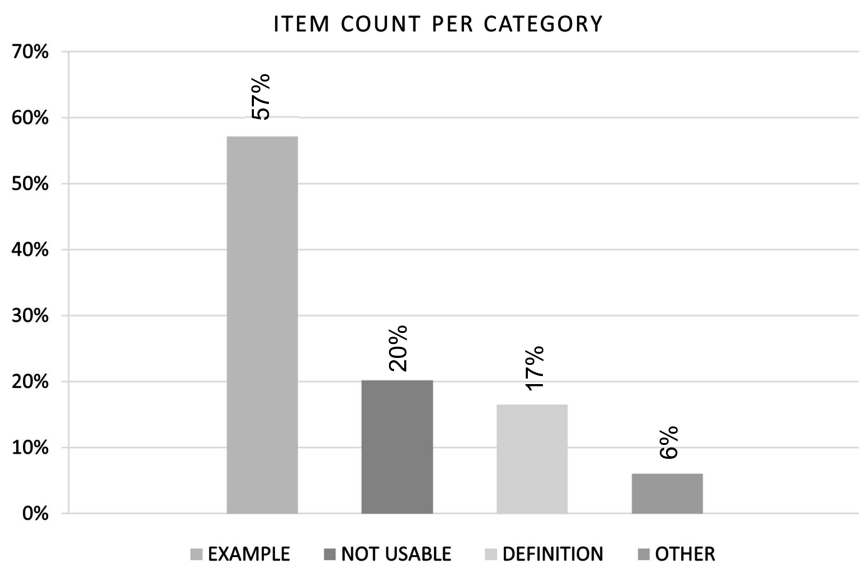

Figure 1. Item count for main categories in %.

(7%). Closer analysis of Question #2 shows a general, positive tendency towards sustainable behavior (see Figure 2). Most perceptions fell into the category "eco-friendly (44%). 14% of the items were classified as "no/ no answer", which means students regarded sustainable lifestyles as not important. 13% concerned the planet-topic, which means students highlighted the fact that there is only one earth to live on and therefore one planet to save for humankind. The original definition of sustainable behavior, namely, to preserve resources etc. for future generations, was mentioned in 3% of the items.

3.3. "Example" Category

Further analysis of the "example" category throughout all questions showed high item counts for "recycling" (40%) and "environmental protection" (33%, see Figure 3). Most student perceptions addressed using less plastic or reusing plastic waste in packaging or clothing. "Locomotion" (21%) combined items related to means of transport, like taking the bus instead of the car or preferring e-cars to combustion engines. The least rated subcategory, "consumption" (6%), mainly
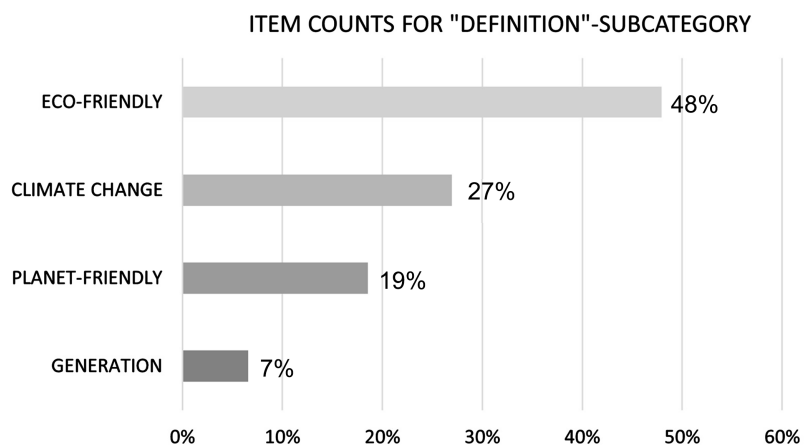
Figure 2. Item count for definition-category in % for all questions.
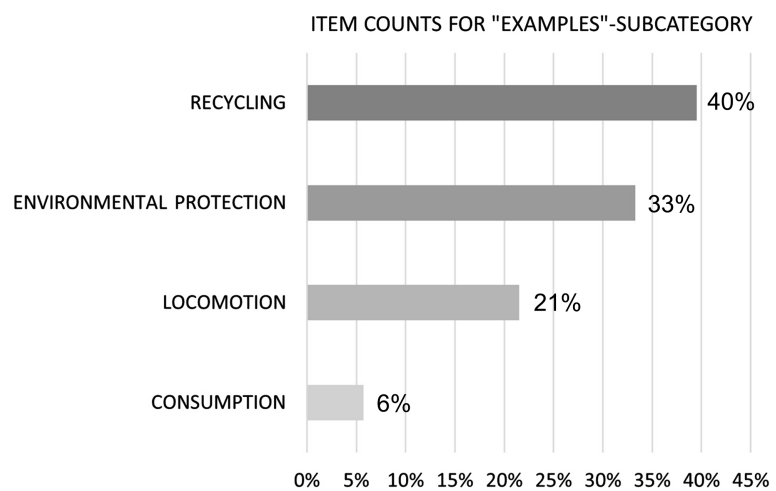
Figure 3. Item Count for example-category in % for all questions.

referred to food. Most items were either for buying more organic products or eating less meat in general.

3.4. Sustainable Lifestyles

Closer analysis of Question #4 confirms a general, positive tendency towards more sustainable behavior (see Figure 4). 13% of the items were classified as "no/no answer". "Recycling" (37%) and "Locomotion" (28%) were the highest rated categories. "Environmental Protection" (7%) and "Consumption" (5%) the least rated ones.

In a separate analysis items were not categorized regarding their content, but their wording. They were rated as "positive" if they promoted certain behavior like "riding the bike more often" or "negative", if they opposed certain behavior, like "stop eating meat". Most of the items were rated negative (62%, see Figure 5).

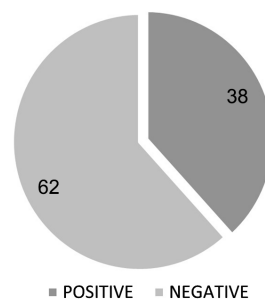## 3.5. Correlations

Significant correlations appear between response pattern and gender ($p = 0.031$). Female students gave an average of $M = 12.83$ (±6.9) meaningful responses; male students $M = 10.54$ (±5.24).
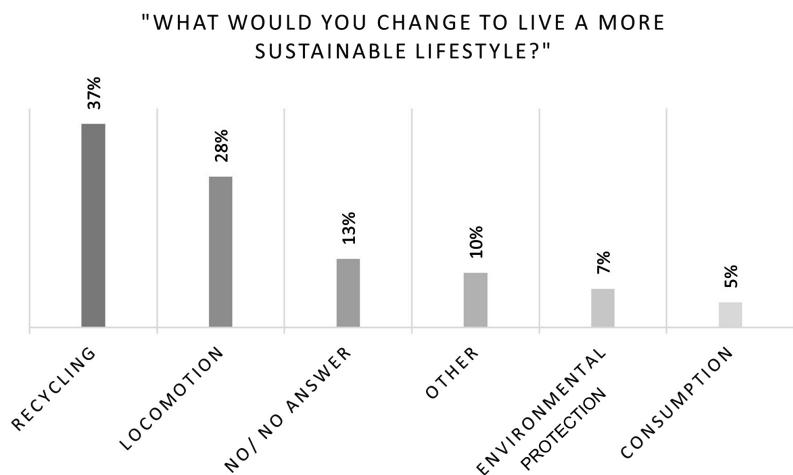
Figure 4. Item count for example-category in % for question #4.

Figure 5. Positive and negative items in %.

It can be concluded that the developed category system allowed for a practical quantification of the data in practice. The descriptions and anchor examples of the categories have led to excellent reliability results, which means that the category system can be considered valid. The data suggests that students primarily provide examples of sustainable actions and sustainability concepts, but rarely concise definitions. Additionally, the environmental dimension is clearly predominant and social and economic aspects are almost completely overlooked. It is also noteworthy that the students seem to perceive little room for agency on their part. It can also be deduced from their statements that they probably have a negative attitude toward sustainability concepts or perceive them as restrictions rather than opportunities. The correlation analysis showed that girls expressed themselves more frequently or more diversely than boys.

4. Discussion

Young students seem to have conceptional gaps regarding the multidimensional model of sustainable development. Most of the items refer to environmental protection and environmental problems, which means that *sustainable* is used synonymously to *environmentally friendly.* This is in contradiction to earlier studies where 5th-graders distinguished the term sustainability from environmental protection in a quantitative questionnaire (Fiedler et al., 2021). The predominance of the ecological dimension, however, is in line with literature on student ideas (Benninghaus et al., 2018; Fiedler et al., 2020; Stössel et al., 2021). In our data students rarely provided definitions of sustainable behavior, and if so, they seldomly included intergenerational and interdimensional aspects. In the context of this study, it was not possible to compare factual knowledge directly with student perceptions. Such conflicting statements should, however, be discussed in subsequent studies.

4.1. "Sustainable" Is Synonymous to "Eco-Friendly"

More than two thirds of the analyzed items are related to environmentally friendly or climate friendly behavior. This supports previous studies showing that young students focus on environmental aspects of sustainability (Schauss & Sprenger, 2021; Schmid & Bogner, 2018b; Walshe, 2013). 67% of the "definition" category and 77% of the "example" category were distributed among various subcategories covering ecological aspects. This shows a great diversity of student perceptions regarding the ecological dimension. Parts of the "consumption" category can be attributed to economic aspects of ESD. However, it can be assumed that "organic products" were mentioned for environmental or animal welfare reasons (Dornhoff et al., 2020). The social sector may have appeared in the form of intergenerational aspects of sustainable behavior. Nevertheless, such items account for less than 0.5% of the item set. Sustainable behavior refers to many different methods and levels, such as consumer behavior, energy consumption, means of transportation, leisure activities, and nutrition, so that students can hardly be expected to cover all categories. Nevertheless, this is where

more qualitatively oriented studies could pick up in order to follow up with students about different behaviors. Although there are different theoretical bases for sustainability education, the different approaches agree that sustainable development is only successful if all dimensions are covered. For instance, there are many examples of how environmental protection can succeed in the long term only in combination with social equity and security. By implication, humans are dependent on ecosystem services in economic terms. Therefore, it is important to address this issue by ensuring that the interconnection of ecological, economic and social dimensions is taught in ESD from the start. Student-related topics, such as saving water in everyday life or waste separation, should therefore not only be approached from one perspective, but always in connection with all dimensions of sustainable behavior (Benninghaus et al., 2018; Schmid & Bogner, 2018a).

The *Sustainable Development Education* strategy specifies five fundamental principles of sustainability: living within environmental limits; achieving a sustainable economy; ensuring a strong, healthy, and just society; using sound science responsibility; and promoting good governance (UNSD, 2017). In this study, participants primarily mentioned the first two aspects. It appears that the economic and, above all, social and cultural aspects of sustainability are not yet present in adolescent student perceptions. This could be related to the German curriculum, which prioritizes ecological topics in lower grades. However, since most students named "media" as their main source of information about sustainability, this needs further clarification. It seems generally advisable, however, to adapt the curriculum for younger students in such a way that more ESD dimensions are covered at an early stage. For example, the Swedish curriculum for ESD could be used as a model, where all dimensions are covered as early as preschool age as part of a holistic approach (Borg & Samuelsson, 2022).

The UNs' definition of sustainable development explicitly includes the needs of future generations (UNESCO, 2019). However, students rarely voiced the intention to preserve resources for future generations, e.g., by using renewable energy sources. Students struggle to make connections between global problems and their own (Keselman et al., 2012). The ability to assess long-term consequences of behavior develops during adolescence (Shubert et al., 2020). Initially, there are two parallel concepts of the future: students distinguish between impacts on their own future and on society's (Hicks & Holden, 1995). This gap remains to be bridged by clarifying that negative effects on a global scale are equivalent to negative effects directly on the students' lifestyles. The ability to think and act in a future-oriented way can be fostered among adolescents (McCue et al., 2019). ESD initiatives should build on this and, in addition to improvements in the content of social and economic aspects, further expand intergenerational issues.

4.2. Student Perceptions and Possible Sources

More than half of the students indicated that they first encountered the term

sustainability in the media. Other studies of student attitudes have reached similar conclusions (Mills Shaw et al., 2008; Raab & Bogner, 2021). In consequence, a large proportion of students enter the classroom with pre-concepts about this topic and therefore these pre-concepts need acknowledging in teaching efforts. Apart from that, education as a professional source of information should fill gaps in the pre-concepts. Apart from that, it seems alarming that the school does not appear as a primary source of information. Sustainability concepts appear in German elementary school curricula. These findings indicate that there is a discrepancy between educational concepts and their actual implementation in the classroom. In German speaking contexts, studies have shown that recycling is a popular topic in primary education (Raab & Bogner, 2020).

"Recycling" is the highest ranking in the examples' subcategories. It might appear counterintuitive that students would think about which PE group a plastic package belongs to. However, *recycling* is a popular issue for elementary and middle school ESD programs (Altikolatsi et al., 2021). Most students were familiar with the terminology from advertisement and media. In recent years, packaging shifted to highlighting its reusability or recyclability. Consequently, recycling appears so often because it occurs more frequently both in the school context and in everyday life.

Due to high relevance to everyday life, recycling cycles are a popular introductory topic for sustainable development courses. Elementary school students have been found to mimic the behavior of their caregivers regarding recycling. The influence of school lessons is marginal (Shubert et al., 2020). Students' behavior at this point tends to be unreflective and may not provide insight into environmental attitudes or other pro-environmental behaviors. Nevertheless, a positive trend of student attitudes towards waste separation and recycling can be identified at secondary level (Aklman et al., 2019). In this age group, recycling behavior seems to be more reflective, but specific knowledge on the complex interrelationships of sustainable development is still lacking. For adults, studies suggest a positive relationship between knowledge of waste management and general environmental attitudes (Dhenge et al., 2022). In the Bavarian curriculum "ecosystem forest" is an obligatory topic in 4th grade (Bayerisches Staatsministerium für Unterricht und Kultus, 2014) focusing for instance on tree decline or rainforest deforestation and its consequences. However, a closer look reveals that the students are against forest clearing but cannot give any precise reasons for this. Deforestation and recycling both seem to be popular topics among primary level teachers but seem to be treated superficially. Following a spiral curriculum, the school staff should focus on one topic and address it in recurring projects across subjects and grades (Mathar, 2015; Strachan et al., 2022). This could on the one hand counteract superficial knowledge transfer and on the other hand help to convey not only ecological aspects of sustainability, but also economic and social ones.

The "consumption" category was not mentioned as often as expected and does not seem to reflect the behavior of 10-year-olds. For example, a frequently men-

tioned topic was e-cars. There is no evidence that children can influence the choice of the family car. If they have not had to face this problem themselves, students have likely encountered it in other contexts. Studies have shown that product placements and advertising have a major influence on children's product preferences (Behal & Soni, 2018). Since most students said they were familiar with the terminology from the media, advertising is suggestive. In advertisement, environmentally conscious aspects of a product are regarded as the basis for successful positive branding (Vesal et al., 2021). Other studies report a greater impact on purchase behavior from advertising that does not highlight direct positive effects on buyers, e.g., the special comfort of a car, but the resulting positive impact on the entire community, e.g., e-cars as environmentally friendly alternatives (Jäger & Weber, 2020). Brand advertising increasingly focuses on highlighting sustainable aspects of their products to ensure brand loyalty (Loučanová et al., 2021; Noh & Johnson, 2019). This concept appeals to young target groups, too (Sharma & Joshi, 2019). Therefore, it can be assumed that the students have frequently encountered the term sustainability in advertising. Typical examples from the German market are smart solutions, e-cars, cosmetics with less microplastic and recyclable packaging. The category of sustainable products also comprised meat substitutes and organic foods.

According to current studies, about 5% of German adults live vegan or vegetarian (Paslakis et al., 2020). Even though medical experts emphasize that a vegetarian diet in children may be related to health deficits, an increase in vegetarians and vegans has been reported (Boukid, 2021; Rudloff et al., 2019). Other studies have found that modern vegetarian diets, presumably based on various meat substitutes, show little nutritional disadvantage in children. However, no advantages in terms of diseases or fitness could be found either (Alexy et al., 2021). Although the "meat substitute" category receives a lot of media attention, it covers only a small portion of the items. This seems plausible considering that parents' eating habits have considerable impact on children's eating habits (Mahmood et al., 2021; Scaglioni et al., 2008). In addition to gender differences, evidence suggests that vegetarian children have a higher socioeconomic status (Nieczuja-Dwojacka et al., 2020). It seems as if not just the behavior of parents, but very much the parental home determines the eating preferences of children. No data collection on students' socioeconomic status was approved as part of this study. Commercials for meat substitutes and organic food have increased significantly in recent years (Boukid, 2021). However, items related to environmental-friendly food or organic products make up 1% of the data. Thus, students do not seem to see a connection between food consumption and sustainable behavior (Schoolman et al., 2016). As part of a follow-up study that further illuminates the categories found here, it would be interesting to collect socio-economic data and compare it with items from the nutrition category.

Discrepancies between item count in the *environmental protection* category and the data regarding Q4 ("What would you change to live a more sustainable lifestyle?") provided interesting insight into the students' self-perceived influ-

ence. When asked about the actions they would take themselves, *recycling* and *locomotion* were mentioned most frequently. This suggests that students acknowledge sustainable behavior to be important, they do not seem to attribute power to change to themselves. Thus, they do not think their own actions can have a viable impact on the environment. This conclusion can be drawn from the discrepancy between questions 2 and 4. In question 2 ("Is living sustainably important? Give reasons why/why not."), "yes" is frequently stated, but reasons for approval are rarely given. Similarly, question 4 ("What would you change to live a more sustainable lifestyle?") was frequently answered with "nothing" or synonymous terms. However, it seems questionable that students' daily lives are already as sustainable as possible - so there would be room for improvement, such as more sustainable means of transportation. Contrary to the Fridays-For-Future (FFF) movement's core idea, this target group does not seem to see the opportunity to actively engage in environmental protection and more sustainable lifestyles themselves (Noth & Tonzer, 2022). Recent research suggests that a sense of obligation is a primary factor for FFF demonstrators to participate in pro-environmental actions (Wallis & Loy, 2021). This is where ESD teaching could step in and provide a theoretical basis for adolescent self-efficacy and practical ideas for age-appropriate sustainable actions.

4.3. Gender and Pro-Environmental Perceptions

Studies have shown that women tend to have higher environmental attitudes and environmentally friendly behavior than men (Casaló & Escario, 2018; Pothitou et al., 2016). Our study supports this conclusion. A correlation between topic-related statements and gender as well as school could be revealed. However, by using open-ended questions for surveying student perceptions a lack of response does not necessarily equate to a lack of knowledge. The differences could also stem from gender-specific characteristics of writing ability or response motivation. As mentioned earlier, the category system developed in this study should provide a basis for further investigation. For example, in interviews the problem of writing ability could be avoided.

This could be connected to a differentiation between individual contributions to sustainable behavior and collective contributions. For example, each individual can make a contribution by ensuring that recycling is properly executed. In regions where the appropriate infrastructure must first be provided at a political level individual efforts are much harder to achieve. Thus collective efforts such as suggestions and innovations are needed. The Fridays-For-Future movement is a good example of how such changes can be made bottom-up, i.e. starting from the citizens. In this instance, young people commit themselves to pushing for change on a political and economic level (Wahlström et al., 2020). Alternatively, legislators can define top-down measures and create financial incentives, e.g. by raising the price of not properly separated waste. However, it is important to ensure that citizens—and students—have a basic understanding of such measures. Following the example of waste management, recycling infrastructure

would exists, but implementation at the individual level might fail and thus, the whole system (Azarova et al., 2019; Liebe & Dobers, 2019). This is where the education system should step in and ensure an understanding of sustainable lifestyles including their effects on an individual as well as on a collective level. Our data shows that students tend to have a negative attitude towards sustainable actions. This indicates that they tend to view sustainable actions as top-down, i.e. as being dictated from higher level institutions. In order to bring about effective and long-term changes, students should be made aware of their own responsibility in the system and be given the opportunity to actively participate, e.g. by contributing ideas for a more sustainable school life.

4.4. Educational Implications

The students' general attitude towards sustainable behavior reveals whether sustainable actions are regarded as something that enriches everyday life or as something that limits it. 62% of the item set refer to things they could not do or could no longer do. This is contrasted with positive utterances of how previous actions could be done differently, i.e., instead of "not driving a car" writing "use more public transport". From the point of view of behavioral psychology, changing behavior is related to the individual's basic attitude (Maurer & Bogner, 2020; Schneiderhan-Opel & Bogner, 2019; Stössel et al., 2021). According to the theory of planned behavior, the more positively a person assesses certain behavior, the more willing they are to adapt previous behavior to comply with that very behavior (Ajzen, 1991). Consequently, any change in behavior needs a certain motivation. Effective ESD and STEAM teaching both focus on intrinsic motivation and individual interest (Baierl et al., 2021; Domenici, 2022; Fiedler et al., 2022). Advertising campaigns for sustainable products rely on external motivators such as lower costs due to lower CO_2 taxes. For 10-year-olds, however, these extrinsic factors are not yet motivational boosters. Instead, ESD should focus on fostering students' intrinsic motivation by addressing real-life issues that are relevant to them. One area with a large socio-economic influence of the parental home as well as a certain bottom-up effect is nutrition (Dornhoff et al., 2020). Ideal nutrition and healthy diets are part of the elementary school curriculum in the Bavarian school system. The curriculum does not specify sustainable aspects of food such as CO_2 consumption or transport routes for ideal nutrition. Various components of a healthy diet, such as fruits, could be implemented using mainly local and seasonal examples instead of exotic ones. Thus, healthy choices for students themselves could be linked to clever choices for the society itself.

One way of improving sustainability concepts could be more open science communication and its active integration into the classroom. The lack of exchange of new scientific insights with the public is regarded as a major cause for differences between students' conceptions and scientific perceptions (Schauss & Sprenger, 2021). Especially in the digital age, where information is ubiquitous and available through the Internet, science should be more present. Students distinguish between "school science" and "real science". These expressions are

troubling in terms of co-existing ideas. In this study, the discrepancy between question #2 ("Is living sustainably important?") and #4 ("What would you change to live a more sustainable lifestyle?") provides evidence that coexisting perceptions are also present in this sample group. Consequently, school lessons should be aligned as closely as possible with current topics and issues relevant to the everyday life of the students (Schmid & Bogner, 2018b). The COVID-19 pandemic, for example, provides numerous technical points of reference: Immune response, genetics, recombination of antigens, genetic diversity, biological diversity, to name a few examples. STEM lessons should be inspired by current scientific discourse. Teachers indicate insufficient time and resources are reasons ESD is not based on current issues (Stössel et al., 2021). To reduce the teachers' workload, regular visits to student laboratories that are closer to scientific research are recommended.

In addition, the role of the teacher should not be neglected. Various studies have shown that especially in the field of sustainability education the authenticity of the teacher has a positive influence on the attitudes of the students (Bertschy et al., 2013; Shephard, 2008; Timm & Barth, 2021). The role model function of the teacher could be essential, especially when it comes to showing the students their own scope for action. In question #4 the "environmental protection" category drops to 7%. It can be deduced from this that the students do not see any scope for action of their own in the field of environmental protection. However, the Fridays-For-Future movement has shown that young people get involved and try to make a difference (Noth & Tonzer, 2022). Teachers could act as neutral persons and point out various fields of action or invite representatives of environmental protection organizations into the classroom. In addition to ecologically oriented organizations, economic and social sponsors should be considered.

5. Conclusion

The study reveals that students often equate sustainability with environmental protection, overlooking other dimensions such as social and economic aspects. The predominance of the ecological dimension aligns with previous research. The media is identified as the primary source of students' perceptions of sustainability, highlighting the need for educational efforts to address pre-existing concepts. Recycling and environmental topics are popular among students, but their understanding of sustainability beyond these topics is limited. Gender differences in pro-environmental perceptions were identified and align with previous research. We suggest that the curriculum should cover a broader range of sustainable development dimensions to address these conceptual gaps and pay attention to the students' pre-existing concepts. The data emphasizes the importance of fostering intrinsic motivation and addressing real-life issues relevant to students to promote sustainable behavior. The teachers' role model function could also be a key factor for effective ESD teaching.

6. Outlook

First, it should be addressed that approximately ¼ of the items collected were not usable or not related to the topic. On the one hand, this shows that most of the students could relate to the term "sustainability". On the other hand, it also shows that a considerable part could not give meaningful answers. Due to the explorative character of the study, no generalizations can be made, although some indications are apparent. This study serves as a starting point for further data collection, for example in the form of interviews. Recruiting individual school classes through convenience sampling does not allow generalized conclusions for an entire generation (Etikan, 2016). Future research focusing on adolescents from various age cohorts, schools and cities would provide a deeper understanding. The categories found here could form the basis for interview guidelines (Walshe, 2013).

The eco-friendly aspects of sustainable behavior seem to act as pronounced triggers among students. Ecological aspects of ESD are predominant in most students' perceptions (Schauss & Sprenger, 2021). The ecological dimension could be used as a starting point to make economic and social sustainability more accessible for students. Students seem to have a positive attitude toward environmental programs. However, they do not see environmental protection in their own scope of action. This is where ESD initiatives should pick up and show how to advocate for sustainable development and environmental protection regionally in everyday life and especially as a young person (Bowie et al., 2022; Iwasaki, 2022). The prevailing tendency seems to be that sustainable action implies restrictions on oneself. This is concerning in terms of motivation to adapt one's own behavior (Carmi et al., 2015; Chaudhuri, 2020). Thus, teachers should try not to reinforce this negative attitude. In ESD units, therefore, it should not be pointed out which products should no longer be consumed, but rather sensible and realistic alternatives should be addressed. By incorporating these approaches into educational curricula, institutions can help students develop a deep understanding of sustainability and cultivate behaviors that support a more sustainable society. Education has the potential to inspire lifelong commitments to sustainable living and equip future generations with the tools needed to address global challenges effectively.

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Conflicts of Interest

The authors have no financial or proprietary interests in any material discussed in this article.

Ethics Statement

The research project labelled "Ecosystem Pasture—an introduction to sustainable behavior" was approved by the Bavarian Ministry of Education (IV.7-BO5106/188/17). All data privacy laws were respected. Gender, age and study status of participants were recorded pseudo-anonymously. Since our target group were underage students, parents had to give written consent. Participation was voluntary and meant no disadvantages in the school routine.

Data Availability Statement

Data cannot be shared publicly because of the Bavarian Ministry for Education's guidelines regarding data of underaged participants. Data are available for researchers who meet the criteria for access to confidential data. Access must be confirmed by the Ethics Committee of the University of Bayreuth/ ZMNU. Contact the corresponding author for further information.

Author Contributions

Conceptualization: Sonja T. Fiedler.
Data curation: Sonja T. Fiedler.
Formal analysis: Sonja T. Fiedler.
Funding acquisition: Franz X. Bogner.
Investigation: Sonja T. Fiedler.
Methodology: Sonja T. Fiedler.
Project administration: Sonja T. Fiedler, Franz X. Bogner.
Resources: Sonja T. Fiedler, Thomas Heyne, Franz X. Bogner.
Software: Thomas Heyne.
Supervision: Franz X. Bogner.
Validation: Sonja T. Fiedler, Thomas Heyne.
Visualization: Sonja T. Fiedler.
Writing-Review & Editing: Thomas Heyne, Franz X. Bogner.
Writing-original draft: Sonja T. Fiedler.

References

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes, 50,* 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

Aklman, E., Barroso, L., Capraro, M. M., Creasy, T., Fleming, K., He, W., Hong, L., & Williams, A. M. (2019). Recycling Plastics: Middle School Students Create Solutions during a Summer Camp. *European Journal of STEM Education, 4,* Article No. 10. https://eric.ed.gov/?id=EJ1237508 https://doi.org/10.20897/ejsteme/6341

Alexy, U., Fischer, M., Weder, S., Längler, A., Michalsen, A., Sputtek, A., & Keller, M.

(2021). Nutrient Intake and Status of German Children and Adolescents Consuming Vegetarian, Vegan or Omnivore Diets: Results of the VeChi Youth Study. *Nutrients, 13,* Article No. 1707. https://doi.org/10.3390/nu13051707

Altikolatsi, E., Karasmanaki, E., Parissi, A., & Tsantopoulos, G. (2021). Exploring the Factors Affecting the Recycling Behavior of Primary School Students. *World, 2,* 334-350. https://doi.org/10.3390/world2030021

Ayene, M., Krick, J., Damitie, B., Ingerman, A., & Thacker, B. (2019). A Holistic Picture of Physics Student Conceptions of Energy Quantization, the Photon Concept, and Light Quanta Interference. *International Journal of Science and Mathematics Education, 17,* 1049-1070. https://doi.org/10.1007/s10763-018-9906-y

Azarova, V., Cohen, J., Friedl, C., & Reichl, J. (2019). Designing Local Renewable Energy Communities to Increase Social Acceptance: Evidence from a Choice Experiment in Austria, Germany, Italy, and Switzerland. *Energy Policy, 132,* 1176-1183. https://doi.org/10.1016/j.enpol.2019.06.067

Baierl, T. M., Bonine, K., Johnson, B., & Bogner, F. X. (2021). Biosphere 2 as an Informal Learning Platform to Assess Motivation, Fascination, and Cognitive Achievement for Sustainability. *Studies in Educational Evaluation, 70,* Article ID: 101061. https://doi.org/10.1016/j.stueduc.2021.101061

Bayerisches Staatsministerium für Unterricht und Kultus (2014). *LehrplanPLUS.* https://www.lehrplanplus.bayern.de/schulart/gymnasium

Behal, M., & Soni, P. (2018). Media Use and Materialism: A Comparative Study of Impact of Television Exposure and Internet Indulgence on Young Adults. *Management and Labour Studies, 43,* 247-262. https://doi.org/10.1177/0258042X18791613

Benninghaus, J. C., Kremer, K., & Sprenger, S. (2018). Assessing High-School Students' Conceptions of Global Water Consumption and Sustainability. *International Research in Geographical and Environmental Education, 27,* 250-266. https://doi.org/10.1080/10382046.2017.1349373

Bertschy, F., Künzli, C., & Lehmann, M. (2013). Teachers' Competencies for the Implementation of Educational Offers in the Field of Education for Sustainable Development. S*ustainability, 5,* 5067-5080. https://doi.org/10.3390/su5125067

Bloodhart, B., & Swim, J. K. (2020). Sustainability and Consumption: What's Gender Got to Do with It? *Journal of Social Issues, 76,* 101-113. https://doi.org/10.1111/josi.12370

Bodner, G., Klobuchar, M., & Geelan, D. (2001). The Many Forms of Constructivism. *Journal of Chemical Education, 78,* No. 8. https://doi.org/10.1021/ed078p1107.4

Borg, F., & Samuelsson, I. P. (2022). Preschool Children's Agency in Education for Sustainability: The Case of Sweden. *European Early Childhood Education Research Journal, 30,* 147-163. https://doi.org/10.1080/1350293X.2022.2026439

Bos, W., & Tarnai, C. (1999). Content Analysis in Empirical Social Research. *International Journal of Educational Research, 31,* 659-671. https://www.learntechlib.org/p/203414/ https://doi.org/10.1016/S0883-0355(99)00032-4

Boukid, F. (2021). Plant-Based Meat Analogues: From Niche to Mainstream. *European Food Research and Technology, 247,* 297-308. https://doi.org/10.1007/s00217-020-03630-9

Bowie, A., Zhou, W., Tan, J., White, P., Stoinski, T., Su, Y., & Hare, B. (2022). Motivating Children's Cooperation to Conserve Forests. *Conservation Biology, 36,* e13922. https://doi.org/10.1111/cobi.13922

Boyes, E., & Stanisstreet, M. (1990). Pupils' Ideas Concerning Energy Sources. *Interna-*

tional Journal of Science Education, 12, 513-529.
https://doi.org/10.1080/0950069900120505

Brundtland, G. H. (1987). *Presentation of the Report of the World Commission on Environment and Development to the Commission of the European Communities, the EC and EFTA Countries.* WCED.

Carmi, N., Arnon, S., & Orion, N. (2015). Transforming Environmental Knowledge into Behavior: The Mediating Role of Environmental Emotions. *The Journal of Environmental Education, 46,* 183-201. https://doi.org/10.1080/00958964.2015.1028517

Casaló, L. V., & Escario, J. J. (2018). Heterogeneity in the Association between Environmental Attitudes and Pro-Environmental Behavior: A Multilevel Regression Approach. *Journal of Cleaner Production, 175,* 155-163.
https://doi.org/10.1016/j.jclepro.2017.11.237

Chaudhuri, J. D. (2020). Stimulating Intrinsic Motivation in Millennial Students: A New Generation, a New Approach. *Anatomical Sciences Education, 13,* 250-271.
https://doi.org/10.1002/ase.1884

Cimer, S. O., Cimer, A., & Ursavas, N. (2011). Student Teachers' Conceptions about Global Warming and Changes in Their Conceptions during Pre-Service Education: A Cross Sectional Study. *Educational Research and Reviews, 6,* 592-597.
https://eric.ed.gov/?id=EJ946279

Cohen, J. (1960). A Coefficient of Agreement for Nominal Scales. *Educational and Psychological Measurement, 20,* 37-46. https://doi.org/10.1177/001316446002000104

de Kock, A., Sleegers, P., & Voeten, M. J. M. (2004). New Learning and the Classification of Learning Environments in Secondary Education. *Review of Educational Research, 74,* 141-170. https://doi.org/10.3102/00346543074002141

DETR Report (2000). *Sustainable Development: What It Is and What You Can Do?* DETR.

Dhenge, S. A., Ghadge, S. N., Ahire, M. C., Gorantiwar, S. D., & Shinde, M. G. (2022). Gender Attitude towards Environmental Protection: A Comparative Survey during COVID-19 Lockdown Situation. *Environment, Development and Sustainability, 24,* 13841-13886. https://doi.org/10.1007/s10668-021-02015-6

Domenici, V. (2022). STEAM Project-Based Learning Activities at the Science Museum as an Effective Training for Future Chemistry Teachers. *Education Sciences, 12,* Article No. 30. https://doi.org/10.3390/educsci12010030

Dornhoff, M., Hörnschemeyer, A., & Fiebelkorn, F. (2020). Students' Conceptions of Sustainable Nutrition. *Sustainability, 12,* Article No. 5242.
https://doi.org/10.3390/su12135242

Driver, R. (1989). Students' Conceptions and the Learning of Science. *International Journal of Science Education, 11,* 481-490. https://doi.org/10.1080/0950069890110501

Dzialo, L. (2017). The Feminization of Environmental Responsibility: A Quantitative, Cross-National Analysis. *Environmental Sociology, 3,* 427-437.
https://doi.org/10.1080/23251042.2017.1327924

Ekins, P., Simon, S., Deutsch, L., Folke, C., & de Groot, R. (2003). A Framework for the Practical Application of the Concepts of Critical Natural Capital and Strong Sustainability. *Ecological Economics, 44,* 165-185.
https://doi.org/10.1016/S0921-8009(02)00272-0

Etikan, I. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics, 5,* 1-4.
https://doi.org/10.11648/j.ajtas.20160501.11

Faize, F. A., & Akhtar, M. (2020). Addressing Environmental Knowledge and Environmental Attitude in Undergraduate Students through Scientific Argumentation. *Journal of Cleaner Production, 252,* Article ID: 119928. https://doi.org/10.1016/j.jclepro.2019.119928

Fidalgo, P., Thormann, J., Kulyk, O., & Lencastre, J. A. (2020). Students' Perceptions on Distance Education: A Multinational Study. *International Journal of Educational Technology in Higher Education, 17,* Article No. 18. https://doi.org/10.1186/s41239-020-00194-2

Fiedler, S. T., Heyne, T., & Bogner, F. X. (2020). Explore Your Local Biodiversity—How School Grounds Evoke Visions of Sustainability. *The American Biology Teacher, 82,* 606-613. https://doi.org/10.1525/abt.2020.82.9.606

Fiedler, S. T., Heyne, T., & Bogner, F. X. (2021). COVID-19 and Lockdown Schooling: How Digital Learning Environments Influence Semantic Structures and Sustainability Knowledge. *Discover Sustainability, 2,* Article No. 32. https://doi.org/10.1007/s43621-021-00041-y

Fiedler, S. T., Heyne, T., & Bogner, F. X. (2022). Closing the Gap: Potentials of ESE Distance Teaching. *Sustainability, 14,* Article No. 8330. https://doi.org/10.3390/su14148330

Geiger, S. M., Geiger, M., & Wilhelm, O. (2019). Environment-Specific vs. General Knowledge and Their Role in Pro-Environmental Behavior. *Frontiers in Psychology, 10,* Article 718. https://doi.org/10.3389/fpsyg.2019.00718

Hicks, D., & Holden, C. (1995). Exploring the Future: A Missing Dimension in Environmental Education. *Environmental Education Research, 1,* 185-193. https://doi.org/10.1080/1350462950010205

Hoppe, T., Renkl, A., Seidel, T., Rettig, S., & Rieß, W. (2020). Exploring How Teachers Diagnose Student Conceptions about the Cycle of Matter. *Sustainability, 12,* Article No. 4184. https://doi.org/10.3390/su12104184

Imran, S., Alam, K., & Beaumont, N. (2014). Reinterpreting the Definition of Sustainable Development for a More Ecocentric Reorientation. *Sustainable Development, 22,* 134-144. https://doi.org/10.1002/sd.537

Iwasaki, S. (2022). Effects of Environmental Education on Young Children's Water-Saving Behaviors in Japan. *Sustainability, 14,* Article No. 3382. https://doi.org/10.3390/su14063382

Jäger, A. K., & Weber, A. (2020). Can You Believe It? The Effects of Benefit Type versus Construal Level on Advertisement Credibility and Purchase Intention for Organic Food. *Journal of Cleaner Production, 257,* Article ID: 120543. https://doi.org/10.1016/j.jclepro.2020.120543

Jaimes, P., Libarkin, J. C., & Conrad, D. (2020). College Student Conceptions about Changes to Earth and Life over Time. *Life Sciences Education, 19,* Article No. ar35. https://doi.org/10.1187/cbe.19-01-0008

Kaiser, F. G., & Roczen, N. (2008). Competence Formation in Environmental Education: Advancing Ecology-Specific rather than General Abilities. *Umweltpsychologie, 12,* 56-70.

Keselman, A., Levin, D. M., Hundal, S., Kramer, J. F., Matzkin, K., & Dutcher, G. (2012). Teaching Environmental Health Science for Informed Citizenship in the Science Classroom and Afterschool Clubs. *The International Journal of Science in Society, 3,* 31-44. https://doi.org/10.18848/1836-6236/CGP/v03i03/51346

Kilinc, A., Yeşiltaş, N. K., Kartal, T., Demiral, Ü., & Eroğlu, B. (2013). School Students'

Conceptions about Biodiversity Loss: Definitions, Reasons, Results and Solutions. *Research in Science Education, 43,* 2277-2307. https://doi.org/10.1007/s11165-013-9355-0

Kowasch, M., & Lippe, D. F. (2019). Moral Impasses in Sustainability Education? Empirical Results from School Geography in Austria and Germany. *Environmental Education Research, 25,* 1066-1082. https://doi.org/10.1080/13504622.2018.1557112

Landis, J. R., & Koch, G. G. (1977). The Measurement of Observer Agreement for Categorical Data. *Biometrics, 33,* 159-174. https://doi.org/10.2307/2529310

Liebe, U., & Dobers, G. M. (2019). Decomposing Public Support for Energy Policy: What Drives Acceptance of and Intentions to Protest against Renewable Energy Expansion in Germany? *Energy Research & Social Science, 47,* 247-260.
https://doi.org/10.1016/j.erss.2018.09.004

Liobikiene, G., Balezentis, T., Streimikiene, D., & Chen, X. (2019). Evaluation of Bio-economy in the Context of Strong Sustainability. *Sustainable Development, 27,* 955-964. https://doi.org/10.1002/sd.1984

Loučanová, E., Šupín, M., Čorejová, T., Repková-Štofková, K., Šupínová, M., Štofková, Z., & Olšiaková, M. (2021). Sustainability and Branding: An Integrated Perspective of Eco-Innovation and Brand. *Sustainability, 13,* Article No. 732.
https://doi.org/10.3390/su13020732

Lucero, M. M., Delgado, C., & Green, K. (2020). Elucidating High School Biology Teachers' Knowledge of Students' Conceptions Regarding Natural Selection. *International Journal of Science and Mathematics Education, 18,* 1041-1061.
https://doi.org/10.1007/s10763-019-10008-1

Mahmood, L., Flores-Barrantes, P., Moreno, L. A., Manios, Y., & Gonzalez-Gil, E. M. (2021). The Influence of Parental Dietary Behaviors and Practices on Children's Eating Habits. *Nutrients, 13,* Article No. 1138. https://doi.org/10.3390/nu13041138

Mathar, R. (2015). Project Variety and Established Structures: Development and Actual Practice of ESD in Germany. In R. Jucker, & R. Mathar (Eds.), *Schooling for Sustainable Development: Vol. 6. Schooling for Sustainable Development in Europe: Concepts, Policies and Educational Experiences at the End of the UN Decade of Education for Sustainable Development* (pp. 123-134). Springer.
https://doi.org/10.1007/978-3-319-09549-3_8

Maurer, M., & Bogner, F. X. (2020). First Steps towards Sustainability? University Freshmen Perceptions on Nature versus Environment. *PLOS ONE, 15,* e0234560.
https://doi.org/10.1371/journal.pone.0234560

Maurer, M., Koulouris, P., & Bogner, F. X. (2020). Green Awareness in Action—How Energy Conservation Action Forces on Environmental Knowledge, Values and Behaviour in Adolescents' School Life. *Sustainability, 12,* Article No. 955.
https://doi.org/10.3390/su12030955

Mayring, P. (2015). Qualitative Content Analysis: Theoretical Background and Procedures. In A. Bikner-Ahsbahs, C. Knipping, & N. Presmeg (Eds.), *Approaches to Qualitative Research in Mathematics Education. Advances in Mathematics Education* (pp. 365-380). Springer. https://doi.org/10.1007/978-94-017-9181-6_13

McCue, R., McCormack, T., McElnay, J., Alto, A., & Feeney, A. (2019). The Future and Me: Imagining the Future and the Future Self in Adolescent Decision Making. *Cognitive Development, 50,* 142-156. https://doi.org/10.1016/j.cogdev.2019.04.001

Mills Shaw, K. R., van Horne, K., Zhang, H., & Boughman, J. (2008). Essay Contest Reveals Misconceptions of High School Students in Genetics Content. *Genetics, 178,* 1157-1168. https://doi.org/10.1534/genetics.107.084194

Newman, K. P., & Trump, R. K. (2023). Addressing the Eco-Gender Gap in Men through Power and Sustainability Self-Efficacy. *Journal of Brand Management, 30,* 261-274. https://doi.org/10.1057/s41262-022-00300-x

Nieczuja-Dwojacka, J., Klemarczyk, W., Siniarska, A., Kozieł, S., & Szysz, T. (2020). Socio-Economic Determinants of the Somatic Development and Reaction Time of Vegetarian and Non-Vegetarian Children. *Anthropologischer Anzeiger, 77,* 137-146. https://doi.org/10.1127/anthranz/2020/1107

Noh, M., & Johnson, K. K. P. (2019). Effect of Apparel Brands' Sustainability Efforts on Consumers' Brand Loyalty. *Journal of Global Fashion Marketing, 10,* 1-17. https://doi.org/10.1080/20932685.2018.1550006

Norström, A. V., Cvitanovic, C., Löf, M. F., West, S., Wyborn, C., Balvanera, P., Bednarek, A. T., Bennett, E. M., Biggs, R., Bremond, A. de, Campbell, B. M., Canadell, J. G., Carpenter, S. R., Folke, C., Fulton, E. A., Gaffney, O., Gelcich, S., Jouffray, J. B., Leach, M. et al. (2020). Principles for Knowledge Co-Production in Sustainability Research. *Nature Sustainability, 3,* 182-190. https://doi.org/10.1038/s41893-019-0448-2

Noth, F., & Tonzer, L. (2022). Understanding Climate Activism: Who Participates in Climate Marches Such as "Fridays for Future" and What Can We Learn from It? *Energy Research & Social Science, 84,* Article ID: 102360. https://doi.org/10.1016/j.erss.2021.102360

Opitz, S. T., Blankenstein, A., & Harms, U. (2017). Student Conceptions about Energy in Biological Contexts. *Journal of Biological Education, 51,* 427-440. https://doi.org/10.1080/00219266.2016.1257504

Paslakis, G., Richardson, C., Nöhre, M., Brähler, E., Holzapfel, C., Hilbert, A., & de Zwaan, M. (2020). Prevalence and Psychopathology of Vegetarians and Vegans—Results from a Representative Survey in Germany. *Scientific Reports, 10,* Article No. 6840. https://doi.org/10.1038/s41598-020-63910-y

Piaget, J. (1964). Part I: Cognitive Development in Children: Piaget Development and Learning. *Journal of Research in Science Teaching, 2,* 176-186. https://doi.org/10.1002/tea.3660020306

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change. *Science Education, 66,* 211-227. https://doi.org/10.1002/sce.3730660207

Pothitou, M., Hanna, R. F., & Chalvatzis, K. J. (2016). Environmental Knowledge, Pro-Environmental Behaviour and Energy Savings in Households: An Empirical Study. *Applied Energy, 184,* 1217-1229. https://doi.org/10.1016/j.apenergy.2016.06.017

Raab, P., & Bogner, F. X. (2020). Microplastics in the Environment: Raising Awareness in Primary Education. *The American Biology Teacher, 82,* 478-487. https://doi.org/10.1525/abt.2020.82.7.478

Raab, P., & Bogner, F. X. (2021). Conceptions of University Students on Microplastics in Germany. *PLOS ONE, 16,* e0257734. https://doi.org/10.1371/journal.pone.0257734

Rainisio, N., Boffi, M., Pola, L., Inghilleri, P., Sergi, I., & Liberatori, M. (2022). The Role of Gender and Self-Efficacy in Domestic Energy Saving Behaviors: A Case Study in Lombardy, Italy. *Energy Policy, 160,* Article ID: 112696. https://doi.org/10.1016/j.enpol.2021.112696

Rudloff, S., Bührer, C., Jochum, F., Kauth, T., Kersting, M., Körner, A., Koletzko, B., Mihatsch, W., Prell, C., Reinehr, T., & Zimmer, K. P. (2019). Vegetarian Diets in Childhood and Adolescence: Position Paper of the Nutrition Committee, German Society for Paediatric and Adolescent Medicine (DGKJ). *Molecular and Cellular Pediatrics, 6,* Article No. 4. https://doi.org/10.1186/s40348-019-0091-z

Scaglioni, S., Salvioni, M., & Galimberti, C. (2008). Influence of Parental Attitudes in the Development of Children Eating Behaviour. *The British Journal of Nutrition, 99,* S22-S25. https://doi.org/10.1017/S0007114508892471

Schauss, M., & Sprenger, S. (2021). Students' Conceptions of Uncertainties in the Context of Climate Change. *International Research in Geographical and Environmental Education, 30,* 332-347. https://doi.org/10.1080/10382046.2020.1852782

Schmid, S., & Bogner, F. X. (2018a). What Germany's University Beginners Think about Water Reuse. *Water, 10,* Article No. 731. https://doi.org/10.3390/w10060731

Schmid, S., & Bogner, F. X. (2018b). Is There More than the Sewage Plant? University Freshmen's Conceptions of the Urban Water Cycle. *PLOS ONE, 13,* e0200928. https://doi.org/10.1371/journal.pone.0200928

Schneiderhan-Opel, J., & Bogner, F. X. (2019). Between Environmental Utilization and Protection: Adolescent Conceptions of Biodiversity. *Sustainability, 11,* Article No. 4517. https://doi.org/10.3390/su11174517

Schoolman, E. D., Shriberg, M., Schwimmer, S., & Tysman, M. (2016). Green Cities and Ivory Towers: How Do Higher Education Sustainability Initiatives Shape Millennials' Consumption Practices? *Journal of Environmental Studies and Sciences, 6,* 490-502. https://doi.org/10.1007/s13412-014-0190-z

Sharma, M., & Joshi, S. (2019). Brand Sustainability among Young Consumers: An AHP-TOPSIS Approach. *Young Consumers, 20,* 314-337. https://doi.org/10.1108/YC-12-2018-0914

Shephard, K. (2008). Higher Education for Sustainability: Seeking Affective Learning Outcomes. *International Journal of Sustainability in Higher Education, 9,* 87-98. https://doi.org/10.1108/14676370810842201

Shubert, J., Wray-Lake, L., & McKay, B. (2020). Looking Ahead and Working Hard: How School Experiences Foster Adolescents' Future Orientation and Perseverance. *Journal of Research on Adolescence, 30,* 989-1007. https://doi.org/10.1111/jora.12575

Singer-Brodowski, M., Brock, A., Etzkorn, N., & Otte, I. (2019). Monitoring of Education for Sustainable Development in Germany—Insights from Early Childhood Education, School and Higher Education. *Environmental Education Research, 25,* 492-507. https://doi.org/10.1080/13504622.2018.1440380

Stössel, J., Baumann, R., & Wegner, E. (2021). Predictors of Student Teachers' ESD Implementation Intention and Their Implications for Improving Teacher Education. *Sustainability, 13,* Article No. 9027. https://doi.org/10.3390/su13169027

Strachan, S., Logan, L., & Marshall, S. (2022). Vertically Integrated Projects for Sustainable Development: Achieving Transformational Action by Embedding Research-Based ESD in Curricula. *Environmental Sciences Proceedings, 15,* Article No. 63. https://doi.org/10.3390/environsciproc2022015063

Sund, P., & Gericke, N. (2020). Teaching Contributions from Secondary School Subject Areas to Education for Sustainable Development—A Comparative Study of Science, Social Science and Language Teachers. *Environmental Education Research, 26,* 772-794. https://doi.org/10.1080/13504622.2020.1754341

Thorn, C. J., Bissinger, K., Thorn, S., & Bogner, F. X. (2016). "Trees Live on Soil and Sunshine!"—Coexistence of Scientific and Alternative Conception of Tree Assimilation. *PLOS ONE, 11,* e0147802. https://doi.org/10.1371/journal.pone.0147802

Timm, J. M., & Barth, M. (2021). Making Education for Sustainable Development Happen in Elementary Schools: The Role of Teachers. *Environmental Education Research, 27,* 50-66. https://doi.org/10.1080/13504622.2020.1813256

UNESCO (2017). *Education for Sustainable Development Goals: Learning Objectives.* UNESCO. https://doi.org/10.54675/CGBA9153

UNESCO (2019). *Framework for the Implementation of Education for Sustainable Development (ESD) beyond 2019.* UNESCO.

UNSD. (2017). *The Sustainable Development Goals Report 2017.* UN.

Vesal, M., Siahtiri, V., & O'Cass, A. (2021). Strengthening B2B Brands by Signalling Environmental Sustainability and Managing Customer Relationships. *Industrial Marketing Management, 92,* 321-331. https://doi.org/10.1016/j.indmarman.2020.02.024

Wahlström, M., de Moor, J., Uba, K., Wennerhag, M., de Vydt, M., Almeida, P., Baukloh, A. et al. (2020). *Surveys of Participants in Fridays for Future Climate Protests on 20-28 September, 2019, in 19 Cities around the World.* OSF.

Wallis, H., & Loy, L. S. (2021). What Drives Pro-Environmental Activism of Young People? A Survey Study on the Fridays for Future Movement. *Journal of Environmental Psychology, 74,* Article ID: 101581. https://doi.org/10.1016/j.jenvp.2021.101581

Walshe, N. (2008). Understanding Students' Conceptions of Sustainability. *Environmental Education Research, 14,* 537-558. https://doi.org/10.1080/13504620802345958

Walshe, N. (2013). Exploring and Developing Student Understandings of Sustainable Development. *Curriculum Journal, 24,* 224-249. https://doi.org/10.1080/09585176.2013.781388

Walters, T., Simkiss, N. J., Snowden, R. J., & Gray, N. S. (2022). Secondary School Students' Perception of the Online Teaching Experience during COVID-19: The Impact on Mental Wellbeing and Specific Learning Difficulties. *The British Journal of Educational Psychology, 92,* 843-860. https://doi.org/10.1111/bjep.12475