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ORIGINAL ARTICLE

Prospective Science Teachers´ Conceptions of Sustainable Nutrition

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ABSTRACT

In the light of increasing pressure on natural resources, growing social inequalities, and enhancing health problems, the concept of sustainable nutrition is becoming increasingly important to overcome several of these challenges. It combines ecological compatibility with social justice and health benefits and thus represents an essential component of sustainable development. Education plays a decisive role in promoting a profound understanding of these complex interrelationships and developing skills for sustainable behavior. This study explores prospective science teachers' understanding of sustainable nutrition through qualitative analysis of individual interviews (n = 15). The findings reveal while nearly all respondents referred to ecological, social, and economic aspects, the health-related and cultural dimensions were considered less frequently. Accordingly, prospective science teachers demonstrated a multi-perspective mindset to sustainable nutrition but did not integrate all perspectives relevant to profound teaching or decision-making. Sustainable nutrition is mostly associated with the concepts of regionality, a meat-free diet, and higher prices. Although students showed an awareness of the complexity of sustainable nutrition, the 28 mentioned sub-concepts were often used in an undifferentiated manner. Critical gaps in knowledge remain, such as an egocentric view instead of global thinking. These insights highlight the need for subject-specific content and interdisciplinary approaches in higher education on sustainable topics.

KEY WORDS: Education for sustainable development, prospective science teachers, qualitative research, student conceptions, sustainable nutrition

INTRODUCTION

Nutrition as a Key to Sustainability

Food plays a central role in the global sustainability debate. The food sector contributes significantly to the degradation of ecosystems, the loss of biodiversity and is a key driver of climate change (IPBES, 2019), as the global food system accounts for around a third of total human-induced greenhouse gas emissions (Crippa et al., 2021). The intensive consumption of resources as well as the widespread use of pesticides and fertilizers lead to far-reaching ecological damage, including deforestation, soil erosion, and species extinction (Willett et al., 2019).

Profound social inequalities in the global food system exist as well. While around 735 million people worldwide are undernourished (FAO et al., 2023), the number of overweight and obese people is rising continuously, and only a minority eat a completely healthy diet – a paradox that highlights the structural inequality in the distribution of resources and access to healthy and sustainable food worldwide. Therefore, it is essential that stakeholders and multipliers, such as teachers, consider the global consequences of their actions. Sustainable nutrition aims to address these challenges by promoting dietary patterns that are ecologically compatible, beneficial to health, and socially equitable (FAO, 2012). Accordingly, an individual and societal change of eating habits is required to achieve the global transformation in the sense of the sustainable development goals (SDGs, United Nations, 2015; Rockström and Sukhdev, 2016). A holistic view of all aspects is necessary to develop sustainable solutions. For consumers, however, it is difficult to understand and implement all aspects of nutrition in the context of sustainability (Van Bussel et al., 2022). There is a need for well-trained professionals who are capable of dealing with, communicating and teaching this complex topic (Silva, 2025).

Teachers are a crucial part in a transforming society in terms of education for sustainable development (ESD) because they empower future generations to tackle upcoming global challenges effectively (Claußnitzer and Paul, 2025; Ghamrawi et al., 2025). As multipliers, they can enable students to make informed decisions and to act sustainably (Nelson et al., 2008; United Nations, 2015). According to school curricula in many countries, science lessons offer numerous opportunities to address healthy nutrition in the light of ESD (Follong et al., 2022; Higgins et al., 2024; Tippmann, 2020).

Empirical research shows that teacher-delivered nutrition education can positively affect students' nutrition knowledge and dietary behaviors when programs are implemented by trained teachers (Cotton et al., 2020). These effects depend

strongly on teachers' competencies and self-efficacy, yet studies from different national contexts indicate that many teachers feel insufficiently prepared to address nutrition education, particularly with regard to sustainability-related dimensions (Jones and Zidenberg-Cherr, 2015). Despite recent progress, substantial gaps remain in practical implementation. ESD topics are still treated superficially rather than being deeply integrated (Holst et al., 2024). Although teachers' attitudes toward the SDGs have improved, structural implementation of ESD continues to be insufficient (Waltner et al., 2020). Sustainable nutrition also remains an abstract concept for several primary school teachers (Maliotou and Liarakou, 2022). A study with over 2,500 students and 500 teachers shows that both groups desire far more ESD in formal education than currently provided (Grund and Brock, 2020). This again highlights the urgent need for a profound and multi-perspective education to empower future teachers as key drivers of informed, sustainable dietary choices.

Defining Sustainable Nutrition

According to the Food and Agriculture Organization of the United Nations (FAO, 2012), *"Sustainable diets are diets with low environmental impact that contribute to food and nutrition security and healthy lives for present and future generations. Sustainable diets protect and respect biodiversity and ecosystems, are culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy, and optimize natural and human resources."*

This definition contains various facets, such as environment, health, culture, economy, and society, addresses present and future generations, and lists specific aspects needed to be considered. In compliance with this, von Koerber's definition of a sustainable diet is based on the five dimensions of economy, ecology, society, health and culture (von Koerber et al., 2017; Figure 1), and therefore includes two more perspectives, in addition to the common three perspectives ecology, society, and economy (Rockström and Sukhdev, 2016). This expanded definition was applied for further data analysis in this study, as in several other studies (Bartsch, 2015; Dornhoff et al., 2020; Yüksel and Yilmaz Önal, 2021).

Literature Review: Conceptions and Dimensions of Sustainable Nutrition

Sustainable nutrition is an extremely broad and controversial topic in human societies. Similarly, consumers as well as future nutrition professionals have numerous conceptions of sustainable nutrition and take various related dimensions into account, which is also reflected in many corresponding studies.

Thereby, consumers still lack key knowledge, such as defining sustainability in the context of diets and to estimate the environmental impact of their food choices (Van Bussel et al., 2022). Similarly, citizens of the UK failed to name essential aspects of a sustainable diet according to FAO (Whittall et al., 2023). For nearly 2/3 of 202 Turkish adults, the principle of sustainable nutrition is totally unknown (Çakır and Garipoğlu, 2020). Lanham and Van Der Pols (2025) concluded in their scoping review, "adolescents understanding of sustainable diets generally appears to be narrow and lacking." Even future nutrition professionals in the UK, Sweden, and Canada have certain issues defining sustainable nutrition according to the World Health Organization (WHO) or FAO, as Ede et al. (2011) stated.

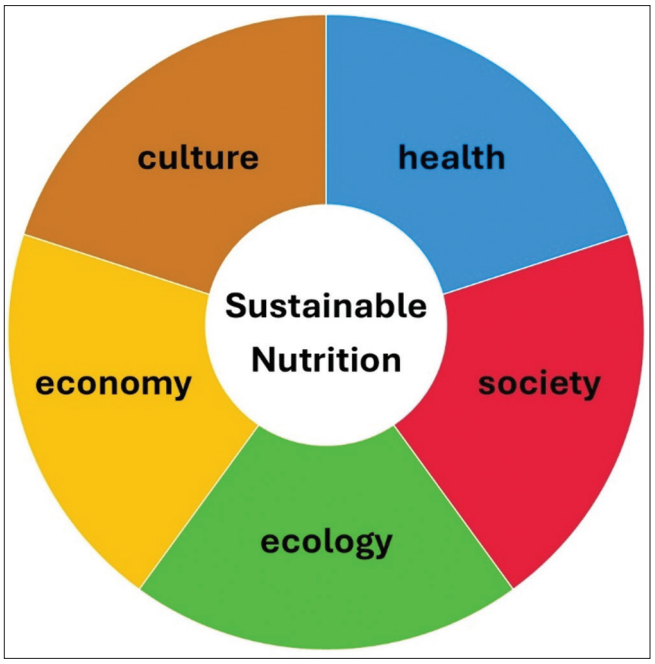

Figure 1: Five dimensions of sustainable nutrition in line with von Koerber (2017), modified by the authors

Several studies examining conceptions of sustainable nutrition have shown that some concepts – such as the belief that "local food or production is always more sustainable" or that "organic and fresh foods are inherently healthier" – are prevalent across many social groups (Damen and Steenbekkers, 2022; Ede et al., 2011; Irazusta-Garmendia et al., 2023). Silva (2025) argues that such simplified ideas can lead to misconceptions, as they were found among university students in Kuwait, who believed that meat consumption has a positive impact on sustainability (AlTarrah et al., 2024). Similarly, misconceptions were found among future nutrition professionals in England, who struggled to accurately assess the role of transport emissions and the implications of excluding palm oil from the diet (Baungaard et al., 2023).

When considering the different dimensions of sustainable nutrition, the health aspect is often regarded as the main feature among consumers (Barone et al., 2019; Dornhoff et al., 2020). Furthermore, studies revealed that consumers in Australia and Turkey are not aware of the environmental impact of their diet (Mann et al., 2018; Yüksel and Yilmaz Önal, 2021). On the other hand, studies conducted with young adults aged between 18 and 25 in Australia and Canada revealed that, besides health, environmental aspects play a particularly important role for them (Ronto et al., 2022; Ruzgys and Pickering, 2025). This was also found among nutrition and dietetic professional

students around the globe in Europe, Asia, Northern America, and Australia, in numerous studies (Baungaard et al., 2023; Burkhart et al., 2020; Ede et al., 2011; Irazusta-Garmendia et al., 2023; Öner et al., 2025). Among prospective science teachers, who will play a key role in imparting this knowledge, the ecological dimension predominates in their conceptions (Bartsch, 2015; Hertrampf and Bender, 2016).

While health and environment play a particularly important role in the perceptions of consumers and future nutrition professionals, social, economic, and cultural aspects are less frequently considered (Dornhoff et al., 2020; Hertrampf and Bender, 2016; Ronto et al., 2022; Van Bussel et al., 2022). Despite of the growing awareness, sustainable nutrition is therefore still widely misunderstood across different age groups and countries, with prevailing misconceptions and a lack of multi-dimensional thinking.

Sustainable Nutrition in Teacher Training Programs

Sustainable nutrition has emerged as a key educational domain at the intersection of public health, environmental sustainability, and social responsibility. As teachers play a pivotal role as mediators between scientific knowledge, curricular frameworks, and students' everyday food-related decisions, the integration of sustainable nutrition into teacher training programs is considered a pre-requisite for effective and long-term implementation in school settings (Bastian et al., 2021; Guillaumie et al., 2020).

Initial teacher training, therefore, represents a critical phase for embedding sustainable nutrition as part of ESD. Research with pre-service teachers demonstrates that attitudes toward sustainable nutrition, personal dietary intentions, and prior exposure to sustainability-related coursework significantly predict the intention to teach sustainable nutrition later in their professional careers (Weber et al., 2021). Moreover, structured training formats – such as project-based learning, workshops, or e-learning programs – have been shown to enhance nutrition knowledge, beliefs, and self-efficacy among both pre-service and in-service teachers (Fernández-Morilla and Albareda-Tiana, 2025; Katsagoni et al., 2019; Salminen et al., 2024).

Qualitative studies further highlight that teachers perceive themselves not only as knowledge transmitters but also as role models whose own eating behaviors and values influence students' learning processes (Hall et al., 2016; Marconi et al., 2022). This underscores the importance of teacher training approaches that integrate cognitive, affective, and behavioral dimensions of sustainable nutrition. Nevertheless, structural barriers, such as crowded curricula, limited institutional support, and a lack of teaching resources continue to hinder systematic implementation (Kempler et al., 2024).

Taken together, the literature suggests that sustainable nutrition should be embedded longitudinally in teacher education programs, combining evidence-based content with experiential and competency-oriented pedagogies. Strengthening teachers' sustainability competencies not only enhances the quality of nutrition education in schools but also contributes to broader societal transformations toward more sustainable food systems (Bastian et al., 2021; Guillaumie et al., 2020).

At the policy level, the United Nations Decade of Action on Nutrition (2016–2025) explicitly emphasizes the integration of nutrition education into curricula and the strengthening of competencies among educators and health professionals as key strategies for improving global nutrition outcomes (see also SDGs 2, 4, 12).

Research Questions

As future agents of change, prospective teachers play a crucial role in shaping sustainable mindsets and behaviors. To design effective teacher education, it is essential to gain insight into their present understanding of sustainable nutrition. Our study, therefore, investigates prospective science teachers' conceptions of sustainable nutrition through individual interviews. The resulting insights aim to inform improvements in higher education. Accordingly, our research questions are as follows:

i) What concepts do prospective science teachers associate with sustainable nutrition?
ii) What dimensions do prospective science teachers consider when it comes to sustainable nutrition?

METHODS

Underlying Theory

Our understanding of learning processes is based on constructivist theory (Fosnot, 2015) and on a revised conceptual change framework (Duit and Treagust, 2003; Strike and Posner, 1992) that integrates a situated perspective (Novak, 2002). The participating students are seen as autonomous learners who actively build their knowledge upon pre-existing conceptions (Duit et al., 2012). Conceptions based on everyday experiences may serve either as resources or as obstacles to learning (Duit and Treagust, 2003). Accordingly, we regard conceptual change as a process of reconstructing conceptions (Duit et al., 2012), wherein these conceptions may be refined, transformed, or newly developed, depending on contextual conditions and individual characteristics. In the present study, we investigate students' conceptions, considering typical perspectives on sustainable nutrition, as a crucial starting point for further learning processes to adapt university courses.

Research Design and Participants

This study uses a qualitative research approach with in-depth semi-structured interviews, enabling a rich exploration of personal conceptions, reasoning strategies, and learning trajectories. This yields contextually grounded insights that are indispensable for understanding complex cognitive and instructional phenomena (Queirós et al., 2017). It offers a suitable and theoretically robust framework for the study's focus.

To become a teacher in Germany, aspirants must attend an average of 10 semesters of studying at university. At the

University of the Probands, students take a basic module in the second semester in which they deal theoretically with ESD and learn the fundamentals, such as the three dimensions of sustainability (society, economy, and ecology) and the SDGs in general. The topic of sustainable nutrition was not covered within the module; therefore, the cultural and health dimensions were not discussed.

Participants were recruited using two criteria: (1) Enrolment in the fifth semester of the teacher education program and (2) successful completion of the second-semester module described above, ensuring comparable prior exposure to relevant content. All students meeting these criteria were invited to participate on a voluntary basis. Participation was independent of course requirements and had no influence on academic evaluation. 15 prospective teachers took part in the study. The students were between 20 and 24 years old, with more females (n = 10) than males (n = 5) participants. The age range was accordingly balanced, and the gender ratio corresponded to the distribution in the biology degree program for prospective teachers.

Instruments

The semi-structured interviews were conducted face-to-face and followed a strict interview guideline. The guideline included four parts with questions about (1) general understanding of sustainability, (2) own sustainable behavior in everyday life, (3) understanding of sustainable nutrition, and (4) assessed importance of sustainable nutrition. Open-ended questions from these parts, as "What does sustainability mean to you?" (1), "Where do you encounter sustainable behavior in everyday life?" (2), "What do you understand by the term sustainable nutrition?" (3) and "How important do you think sustainable nutrition is?" (4), were asked to ensure that responses were as unbiased and diverse as possible. These open questions increase validity by giving participants the opportunity to articulate their experiences and perspectives in their own words (Muenz et al., 2023). The guideline interview method was chosen because it gives the interview a general structure but still leaves room for flexibility (Seidman, 2019). Therefore, it was possible to ask the same guiding questions, but it also allowed to go into more detail in case it was needed. The interview guideline was piloted with n = 3 students and improved in constant consultation with experts in advance. The interview language was German. The results were translated into English by the authors.

Data Collection and Analysis

A written declaration of consent to the collection and processing of the interview data was voluntarily signed by all participants in advance. In doing so, they confirmed that the interview would be recorded, written down, anonymized, evaluated, and published. The interviews were held individually at the university. There was more than 9 h of audio data from 15 interviews. The shortest interview was 17 min, the longest 43 min.

The qualitative data were analyzed via MAXQDA 2024 software using a systematic coding approach (Mayring, 2014), thereby enhancing the replicability and consistency of the results. To make the interpretations independently comprehensible and check their quality, further coders were consulted. Those were researchers from similar scientific backgrounds and familiar with the MAXQDA software (Seidmann, 2019). The intercoder match was 97.32%.

RESULTS

Exemplary Student Statements

The goal of this research project was to gain a deeper understanding of students' existing concepts regarding sustainable nutrition. Within the interviews, the conceptions were discussed, further elaborated, and explained by students. The responses differed in terms of depth, precision, and the respondents' ability to articulate their reasoning. Each prospective teacher made between 7 and 14 statements relating to sustainable nutrition. The following statement about regionality in food reflects a typical interview situation (original transcript excerpt):

Interviewer: *"What does sustainable nutrition mean to you?"*

> Betty: *"(...) For me regional products are sustainable. In Germany, you should not eat apples from New Zealand, for example, which have been flown around the planet, but apples from the local farmer."*

Like 13 other prospective teachers, Betty associated regionality with sustainable nutrition. Most of them argued that regional products have lower emissions caused by transportation (Table 1, sub-concept #1). However, the word "regionality" has always been used in an undifferentiated and purely positive connotation and was used by 12 students directly in connection with seasonality ("I always associate sustainable nutrition a bit with regional and seasonal." Inez, pos. 4). Three participants were unable to elaborate on their understanding of regionality, which remained rather unspecific.

In addition to regional considerations, 13 of 15 prospective teachers identified reduced meat consumption or a predominantly plant-based diet as an essential aspect of sustainable nutrition. The interview with Dorothea clearly illustrates which aspects of livestock farming play a role for her regarding sustainable nutrition:

> Dorothea: *"Eating meat is not very sustainable. When we eat a piece of meat, we are also consuming all the water and fodder crops that the animal has eaten to grow throughout its life. (.) Instead, we could grow something else on the fields that we can eat directly. Then the path is shorter, less water is consumed and less CO_2 is emitted throughout the entire process."*

From this and other statements, the sub-concepts "livestock needs space for food" and "livestock consumes a lot of water" can be derived. In addition, meat consumption was considered unsustainable by respondents due to its harmful effects on their own health and the associated animal suffering, as to be seen in Table 1.

Table 1: The derived main-concepts about sustainable nutrition and their related sub-concepts mentioned in individual interviews with 15 prospective science teachers. The colours indicate the dimension of sustainable nutrition to which the concept mainly is assigned to (see Figure 1). The concepts are sequentially numbered from #1 to #28.

Main-concept	#	Dimensions	Sub-concept	Incidence
Regional products are sustainable	1		Long transportation cause emissions	10
	2		Local products have higher quality	4
	3		The use of regional products strengthens regional jobs	2
Consuming much meat is not sustainable	4		Livestock emits gases	6
	5		Livestock needs space for food	6
	6		Livestock consumes a lot of water	4
	7		Consuming meat let animals suffer	3
	8		Eating meat is harmful to health	2
Sustainable products are expensive	9		Not everybody can afford these products	7
	10		Regional products are expensive	5
	11		Organic products are expensive	4
Food systems should promote social and ethical responsibility	12		Sustainable diet, in general, is expensive	4
	13		One should reflect on animal husbandry practices	6
	14		Trade should be fair	4
	15		Sustainable nutrition involves respecting human rights	3
	16		Resource management is essential for ensuring global food security	3
Nutrition effects the body	17		Nutrition can have a negative impact on the body.	5
	18		Sustainable nutrition can promote health	4
	19		A balanced diet is a sustainable one	4
	20		Highly processed food is unhealthy	3
Producing less waste is sustainable	21		Plastic packaging has to be reduced	5
	22		Wasting food is not sustainable	3
	23		Paper cups are a big source of waste	2
Culture influences nutrition	24		Meat is only eaten out of habit	7
	25		Non-sustainable food tastes good	3
Nature should not be exploited	26		Natural habitats shouldn×t be destroyed	3
	27		Food production depends on natural regeneration	2
	28		Agriculture can damage the soil	1

Beyond environmental and health considerations, the interview excerpt with Sam highlights the relevance of social aspects for prospective teachers:

> Sam: *"For me, sustainable nutrition is about whether the food was produced under humane conditions or on a plantation with poor human rights practices."*

Therefore, the sub-concept "sustainable nutrition involves respecting human rights" was elaborated. Together with the necessity of fair trade, the ensuring of global food security and reflecting animal husbandry, the main-concept "Food systems should promote social and ethical responsibility" was formed, which was addressed by 11 participants. All sub-concepts were subsequently formed inductively from the interview data. The sub-concepts found were afterward assigned to the main-concepts for better structuring.

Students' Conceptions of Sustainable Nutrition

We identified a total of 28 different sub-concepts of sustainable nutrition, which were grouped into 8 overarching main-concepts (Table 1). While this number may seem high, it reflects the multifaceted character of sustainable nutrition and indicates a nuanced understanding among the students.

Considering financial aspects, 11 of the 15 respondents stated that sustainable products are more expensive than non-sustainable food. In this context, regional and organically grown products in particular were perceived as expensive compared to conventional products. Regional products were understood as those that were produced close to the consumer. However, the cultivation method did not play a role here. 9 of 15 respondents associated the reduction of waste with a sustainable diet. In the context of waste production, most respondents mentioned plastic as the greatest hurdle that needs to be overcome. The waste of food by throwing it away was also addressed, especially against the background of global hunger and resource consumption.

Nine people emphasized that sustainable nutrition has an impact on one's own body. An unhealthy diet can cause illness, while a balanced, sustainable diet provides "power," "energy," and "strengthening" for the body and one's own health. Highly processed foods, such as soft drinks and fast food, are considered particularly unsustainable in this context.

Considering cultural aspects, 7 of the respondents stated that they only ate meat under certain circumstances and habits, such as meals with family, on vacation, or while cooking

with friends. Regarding the cultural influence on a sustainable diet, 3 participants stated that non-sustainable food, such as avocados, meat, or chips taste good, which makes it harder to abstain from it.

Dimensions of Sustainable Nutrition Considered by Students

To answer the question, which dimensions were considered, the statements of the prospective teachers were assigned to the five dimensions: Ecology, economy, society, health, and culture, as described below. The numbers in brackets refer to the sub-concepts in Table 1.

Most students already think in terms of various dimensions of sustainable nutrition at the beginning of the practical seminar. The number of students, who addressed the specific dimension, as well as an exemplary excerpt from the transcript, are listed in Table 2. All (n = 15) respondents described ecological aspects of a sustainable diet. Statements which included nature conservation (#26–#28), environmental pollution due to long transportation (sub-concept #1), livestock farming (#4–#6), or sub-concepts from "producing less waste is sustainable" (#21–#23) were assigned to this dimension. Economic aspects were also addressed by all 15 respondents. Mentions relating to production (#3), trade (#14), price (#10–#12), or consumption of sustainable products were placed here. For 14 out of 15 respondents, sustainable nutrition is linked to social aspects. If the students indicated factors, such as education, justice (#9, #15, #22), or food security (#16), this was assigned to society. Eleven respondents recognized that health, that is, prevention of diseases (#8, #17), strengthening health (#18, #19), and low-processed food (#20), is part of sustainable nutrition. 9 students associated sustainability in the context of food and diet with cultural aspects, such as animal welfare (#7, #13), tradition or habit (#24, #25). It became clear that the interviewees addressed various aspects of sustainable nutrition.

Table 2: Addressed dimensions of 15 prospective science teachers

Dimension	Number of participants	Exemplary statement
Ecology	15/15	Sustainable nutrition means to me that we can return the yield that we take so that it does not harm nature. (Susi, pos. 5)
Economy	15/15	You should buy more from a local farmer than from a wholesaler. Therefore, supporting small farms is good for sustainable nutrition. (Dorothea, pos. 5)
Society	14/15	It depends, whether it was grown under humane conditions or whether it came from some kind of plantation, which does not necessarily have the best human rights conditions. (Sam, pos. 5)
Health	11/15	Sustainable nutrition is also the aspect that it is healthy, balanced, that I strengthen my health through it. (Peter, pos. 6)
Culture	9/15	I only eat meat when I'm at home or when I'm cooking with my partner. (Dorothea, pos. 7)

2/15 participants mentioned aspects from three dimensions. In the statements of 7/15 respondents, a reference to four dimensions could be identified. For 6/15 students, the responses could be assigned to all five dimensions of a sustainable diet. In analyzing the second research question, it was shown that prospective science teachers mainly consider ecology, economy, and social issues rather than health and culture in their explanations.

DISCUSSION

Local Perspectives and Conceptual Simplifications in Understanding Sustainable Nutrition

This study aimed to explore prospective science teachers' understanding of sustainable nutrition by identifying their individual concepts of the topic. Accordingly, our first research question is: What concepts do prospective science teachers associate with sustainable nutrition? At first glance, the conceptions found cover a wide range of different main- and sub-concepts relating to sustainable nutrition (Table 1). But a further look showed that some of the concepts are imprecise, somewhat superficial, or overly simplistic, although none of the concepts are technically incorrect (e.g. #1, #2, #10, #12, #14). This mainly involved concepts relating to the topic of "regionality." Respondents used the word "regionality" unreservedly as a synonym for "sustainability." The seemingly great impact of eating regionally as a sustainable food consumption behavior among young adults was also identified by Kamenidou et al. (2019) and Ruzgys and Pickering (2025). The most frequently detected sub-concept our students reported for consuming regional foods is that "long transportation routes cause a lot of greenhouse gases" (#1).

Accordingly, avoiding long transportation routes reduces greenhouse gas emissions and thus benefits the environment. Nonetheless, transportation is only a small part of the overall environmental impact of the food chain (Weber and Matthews, 2008). It is much more important what consumers eat than where it comes from, for example, a meat-heavy diet usually produces significantly more greenhouse gases than a long transportation route (Polleau and Biermann, 2021; Poore and Nemecek, 2018). Under certain circumstances, regional cultivation can also be associated with increased greenhouse gas emissions due to lower productivity or efficiency (Schmitt et al., 2017). A product grown in a greenhouse nearby could have a larger carbon footprint than the same product imported from the country where it grows naturally (Macdiarmid, 2014). The concept of seasonality, which many interviewees link directly to regionality and appears very difficult to separate, has a much greater impact on the environment. In addition to the undifferentiated statements described above, there were elaborate contributions that take into account the complex interactions between several factors. An example can be found in Dorothea's consideration regarding meat consumption or a vegetarian diet, as described in section 3.1. Here, she presented the far-reaching consequences of meat consumption on land

and water use in considerable detail. Overall, it became evident that the depth and level of differentiation in responses varied greatly across respondents and topics.

Many interviews revealed that prospective science teachers tended to think locally rather than globally. This became evident in sub-concept #23, for example, in which the students focused primarily on waste that they encounter or produce in their everyday live ("The trash cans in the library are filled with the paper cups provided by the coffee machines located across the campus." Peter, pos. 4). When discussing plastic and packaging, most examples stemmed from their immediate environment, while the global consequences of plastic waste, such as marine pollution, affecting fertility, or microplastics in organisms were rarely mentioned (Ncube et al., 2021; United Nations Environment Programme, 2018). Similarly, sub-concept #9 referred to the respondents' limited financial resources as college students, which does not allow them to purchase more sustainable products. Only a few participants recognized that other consumers outside the university context also have low incomes, even to consider a sustainable purchase (Darmon and Drewnowski, 2015). Moreover, consumers from low-income countries were not considered at all, which confirms a predominantly local perspective and a lack of global awareness. Overall, the interviewees strongly referred to their own situation as students and had a somewhat egocentric point of view, as they did not consider global issues. This was also found by Dornhoff et al. (2020). In general, young adults between 19 and 30 have a tendency to act and see things in an egocentric way (Frankenberger, 2000). Guerrero et al. (2021) also showed that proximity or personal involvement – in our case, such as the full trash bins or the lack of money – acts as a motivator for commitment. On the other hand, studies show psychological distance in environmental issues, such as climate change, where those affected often perceive the problems as distant in time or space and irrelevant to themselves (Spence et al., 2012).

Overall, these findings suggest that prospective science teachers' conceptions of sustainable nutrition are shaped by a predominantly local and self-referential perspective. This pattern can be interpreted in light of the limited and often implicit integration of sustainable nutrition within teacher education programs. Although nutrition-related topics are addressed across various subject-specific modules, they are rarely framed explicitly within a sustainability-oriented perspective (Bastian et al., 2021). Consequently, prospective science teachers may encounter nutrition-related content in fragmented ways, without systematic support for integrating these elements into a coherent understanding of global food systems and interdependencies (Salminen et al., 2024).

Campbell and Feldpausch (2023) argue that while sustainable food and nutrition education has traditionally been embedded in separate disciplinary perspectives, it requires a systems-oriented approach that explicitly integrates environmental, social, economic, and health-related dimensions. In the absence of such systemic framing, learning processes tend to emphasize isolated factual knowledge rather than fostering a holistic understanding of interconnected global food systems. This lack of explicit curricular anchoring may therefore contribute to the tendency to conceptualize sustainable nutrition primarily in terms of individual consumer choices, rather than as part of broader structural and global food interrelations.

Evidence from teacher education research indicates that this limitation can be addressed through targeted curricular interventions. Fernández-Morilla and Albareda-Tiana (2025) demonstrate that the explicit and practice-oriented integration of sustainable nutrition into initial teacher training promotes the development of sustainability-related competencies, including systems thinking and critical reflection. Taken together, these findings emphasize the need for a more systematic, knowledge-based, and critically reflective implementation of sustainable nutrition within teacher training programs.

Scope and Focus of Sustainability Dimensions Considered by Prospective Teachers

Our second research question addresses the variety of dimensions that prospective teachers consider when thinking about sustainable nutrition. Regarding this, the students showed a relatively broad understanding, as they mentioned various dimensions of sustainability. All students referred to ecological and economic aspects, while 14 out of 15 students mentioned social aspects too, as shown in Table 2. The two dimensions of health and culture were named less frequently (see below).

A comparable study by Bartsch (2015), which surveyed university students of health- and nutrition-related subjects using semi-closed questionnaires, found that although references to ecology were present in almost all (44/50) respondents' answers, only 12 of the 50 students linked sustainable nutrition to economics and 17 to society. Hertrampf and Bender (2016) examined corresponding conceptions of student teachers of home economics and found similar results. Here, most responses on the topic of sustainable nutrition were attributed to the ecological dimension (61%), while economic (13%) and social dimensions (12%) were underrepresented. In contrast, the relatively balanced presence of these three dimensions in our study suggests that the United Nations' 2030 Agenda is possibly showing initial success in transformative and multi-perspective thinking. Since the introduction of the SDGs in 2015 and various ESD programs sustainability issues have been increasingly integrated into school and university curricula (United Nations, 2015). As described in the methods section (chapter 2.2), our participants received prior instruction in the fundamentals of ESD as part of the basic module and were therefore aware of the topic. The lack of a multidimensional understanding identified by Bartsch (2015) and Hertrampf and Bender (2016) may therefore be attributed to the fact that their studies were conducted before the spread of sustainability concepts initiated by Agenda 2030. Although the three dimensions were well represented as a possible result

of previous participation in ESD courses, the concepts were not sufficiently differentiated to the desired extent (cf. chapter 4.1).

In our study, 11 out of 15 participants linked sustainable nutrition with health aspects. Empiric findings on the importance of health vary among students. For example, only 11 of the 50 respondents in Bartsch's study 2015 mentioned health aspects, while in other surveys, health was considered to consumers to be the most important aspect of sustainable nutrition (Barone et al., 2019; Dornhoff et al., 2020; Hoek et al., 2017). This discrepancy reflects that health has only recently begun to play a significant role within ESD. As Agbedahin (2019) noted, the Agenda 2030 and ESD frameworks increasingly emphasize the interconnectedness of human health, environmental health, and sustainability as a central dimension of sustainable development. Similarly, the field of planetary health emphasizes that dietary choices are both health-related and environmentally impactful, making nutrition an important lever for sustainability transformations (Baierl et al., 2025; Shaw et al., 2021). It therefore seems likely that the dimension of health will become even more central to the sustainability debate in the future.

The cultural dimension of sustainable nutrition deserves particular attention. According to UNESCO, culture is defined as a "set of distinctive spiritual, material, intellectual and emotional features of society or a social group, and that it encompasses […] lifestyles, ways of living together, value systems, traditions and beliefs" (UNESCO, 2001). This definition illustrates that social and cultural aspects are closely intertwined. Von Koerber et al. (2017) stated that the cultural dimensions include taste, naturalness, trust, and pleasure. These aspects were also taken into account by 9 of the students in our study. Von Koerber, however, does not specify how ethical considerations should be classified in relation to animal husbandry. Consequently, it remains unclear whether animal welfare belongs to the cultural or the social dimension, and to what extent ethical aspects contribute to sustainable nutrition. The classification of statements concerning animal welfare thus remains ambiguous between these two dimensions.

While comparable studies often do not take the cultural dimension into account at all, in the study from Dornhoff et al. (2020), only 4 out of 46 respondents associated culture with sustainable nutrition – On this basis, the fact that nine out of 15 students in the present study made culture-related statements seems remarkably high in comparison. This suggests that these students, based on their prior knowledge of the multidimensionality of sustainability, consciously incorporated the additional dimensions of health and culture into their reasoning.

The frequent mention of health and cultural aspects further underlines the relevance of von Koerber's extension of the three classical sustainability dimensions. This broader framework enables a more comprehensive conceptualization of sustainable nutrition. In summary, the variety of dimensions identified by the participants reflects an emerging multi-perspective understanding of sustainable nutrition, likely fostered by prior ESD learning experiences, yet still requiring further conceptual depth and integration.

Limitations

This study is subject to several limitations. Since our aim was to investigate prospective science teachers' conceptions, all participants were of similar age, lived in Germany, and have been visiting similar university courses. As a result, the sample was relatively homogeneous, which limits the generalizability of the findings. It cannot be ruled out that the respondents chose to participate because they already had a strong interest in, or prior experience with, sustainable nutrition – either through activities outside the university or as part of their biology disciplinary focus. This may partly explain the comparatively broad knowledge of different dimensions of sustainable nutrition observed in our sample. Moreover, as with all interview-based research, the study relies on self-reported data from participants. Response bias or socially desirable answering may therefore have occurred, potentially introducing minor inaccuracies into the interpretation of the data. Although the interview guideline was largely standardized, interview length – and consequently the level of detail in participants' responses – varied considerably across interviews. This variability may have influenced the depth and comparability of the data.

CONCLUSION AND IMPLICATIONS

This study focused on prospective science teachers. As future multipliers, they bear a special responsibility. They play a pivotal role in fostering sustainable development among future generations. Sustainable nutrition is particularly well-suited to make the complexity of sustainable development tangible, relatable, and understandable in everyday life. It is therefore essential to investigate the extent to which prospective science teachers have already internalized the multifaceted framework of sustainable nutrition and developed a comprehensive and differentiated understanding of it.

Our findings indicate that prospective science teachers already recognize several dimensions of sustainable nutrition and associate them with a broad range of concepts. 13 of the 15 respondents referred to four or five of the dimensions (economy, ecology, society, health, and culture) and drew on aspects from various areas of sustainable nutrition. However, the conceptual analysis revealed that these considerations were sometimes superficial, egocentric, or insufficiently differentiated. In line with the principle of educational reconstruction (Duit et al., 2012), these concepts should be specifically addressed. To ensure that future teachers develop a comprehensive, global, and in-depth understanding of sustainable nutrition, several implications for higher education were derived:

First, university-based teacher education should integrate more extensive, subject-specific scientific content, preferably in cooperation with other disciplines, to cover the entire spectrum of ESD. It could be shown that knowledge about sustainable nutrition had positive explanatory power for the self-efficacy of

prospective science teacher (Weber et al., 2021). Hence, there is a clear need for courses that explicitly address sustainable nutrition and cover topics, such as carbon dioxide balance of food products, cultivation methods, fertilization practices, supply chains, and livestock systems. Previous studies with university students similarly highlight the need for deeper content knowledge due to limited science-specific knowledge in this domain (AlTarrah et al., 2024; De Moraes Prata Gaspar et al., 2023).

Second, because ESD requires global, interconnected, and systemic thinking (Lönngren et al., 2016; United Nations, 2015), teacher education should emphasize understanding the global consequences of individual actions related to sustainable nutrition. Such competencies are unlikely to emerge from isolated modules and instead require coherent, structurally embedded, and evidence-based sustainability approaches across teacher education programs (Bastian et al., 2021; Fernández-Morilla and Albareda-Tiana, 2025). Biology teacher education provides suitable entry points for this integration, including human biology (metabolism), ecology (global resource distribution), and botany (food production). The tendency toward individualized perspectives may reflect broader societal shifts, highlighting the responsibility of higher education to foster globally interconnected viewpoints. Crucially, competencies developed in teacher training must be transferred into school practice to counteract egocentric perspectives, for example by addressing socio-scientific issues, such as organic versus conventional farming, genetically modified crops, or meat consumption through structured debates, role-playing, or life cycle assessment, which have been shown to promote perspective taking and systemic thinking (Buchs and Blanchard, 2011; Tytler, 2012; Viere et al., 2021).

Third, university teaching should engage more thoroughly with food-related myths and marketing claims. Students need opportunities to critically examine everyday terminology and advertising messages. This applies particularly to the concept of regionality. The notion of "regional" food should be systematically discussed, especially with regard to the common misconception that regional products are inherently more climate-friendly. Understanding when and why regionality does not necessarily correspond to a lower environmental impact should be an explicit part of education.

In summary, sustainable nutrition can be regarded as a highly suitable topic for ESD, as it integrates multiple dimensions while remaining closely connected to everyday life. The increasing recognition it has gained in recent years is a promising development for future education efforts.

ETHICAL APPROVAL

This study was in approved by the ethics committee of the Julius-Maximilians-University of Wuerzburg. The project has received approval from the institution's ethics committee for both its planning and execution. All participating students voluntarily signed an informed consent form that outlined the purpose of the research, ensured confidentiality, and clarified that the results and data would be used solely for academic and research purposes.

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